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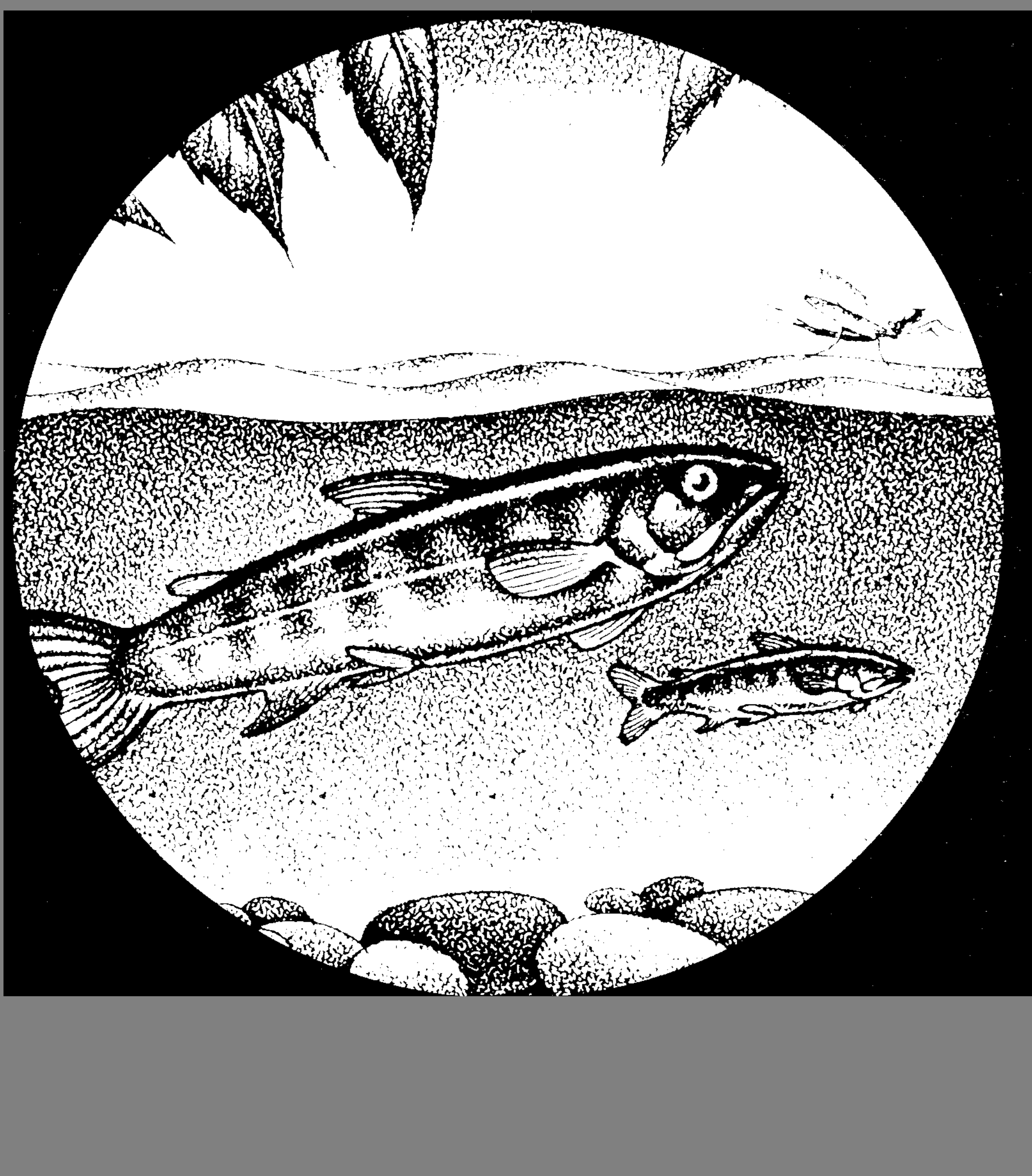
Smolt Monitoring at the Head of Lower Granite Reservoir and Lower Granite Dam



Annual Report For 1991 Operations

U.S. Department of Energy
Bonneville Power Administration
Division of Fish & Wildlife

Idaho Department of Fish and

SMOLT MONITORING AT THE HEAD OF LOWER GRANITE RESERVOIR AND LOWER GRANITE DAM

1991 Annual Report

by

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Idaho Department of Fish and Game

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ABSTRACT

This project monitored the daily passage of chinook salmon Oncorhynchus tshawytscha and steelhead trout Oncorhynchus mykiss smolts during the 1991 spring outmigration at migrant traps on the Snake River and the Clearwater River.

Chinook salmon catch at the Snake River trap was similar to 1987, 1988, and 1990, drought years, but considerably less than 1989, a near normal flow year. Trapping effort was the same during the five-year period. Hatchery steelhead trout catch was similar to 1988 through 1990. Wild steelhead trout catch was 20% greater than in any previous year. In 1991, operations at the Snake River trap and a new screw trap were extended through August to collect summer-migrating age 0 chinook. Operation of the screw trap began on July 2. The screw trap did not collect any age 0 chinook due to extremely low discharge after that date. The differentiation of age 0 chinook from spring and summer chinook (age 1) using physical characteristics did not begin until June 16 and 93 age 0 chinook were collected at the Snake River trap.

Chinook salmon catch at the Clearwater River trap was the second lowest in the past five years. Hatchery steelhead trout trap catch was similar to the second highest catch, which occurred in 1988, but about three times lower than in 1990, which had the highest trap catch. Wild steelhead trout trap catch was similar to the second highest and about half of the highest.

Fish tagged with Passive Integrated Transponder (PIT) tags at the Snake River trap were recovered at the three dams with PIT tag detection systems (Lower Granite, Little Goose, and McNary dams). Cumulative recovery at the three dams for fish marked at the Snake River trap was 68.2% for chinook salmon, 89.7% for hatchery steelhead trout, and 83.3% for wild steelhead trout. Cumulative recovery at the three dams for fish PIT-tagged at the Clearwater River trap was 60.5% for chinook salmon, 83.8% for hatchery steelhead trout, and 74.1% for wild steelhead trout.

Travel time (d) and migration rate (km/d) through Lower Granite Reservoir for PIT-tagged chinook salmon and steelhead trout, marked at the head of the reservoir, were affected by discharge. Statistical analysis showed that a two-fold increase in discharge increased migration rate by 2.3 times for PIT-tagged chinook salmon released from the Snake River trap and for PIT-tagged chinook salmon released from the Clearwater River trap. A two-fold increase in discharge increased migration rate by 3.1 times for PIT-tagged hatchery steelhead trout released from the Snake River trap. Hatchery steelhead trout marked at the Clearwater River trap migrated 1.5 times faster with a two-fold increase in discharge. A two-fold increase in discharge increased migration rate by 2.2 times for PIT-tagged wild steelhead trout released from the Snake River trap and by 2.1 times for PIT-tagged wild steelhead trout released from the Clearwater River trap.

Chinook salmon, hatchery steelhead trout, and wild steelhead trout captured in the Snake River trap had a minimum survival estimate to Lower Granite Dam that was 5.9 to 7.9 percentage points higher than fish that were collected in the Clearwater River trap. This difference may be attributed to the distance fish traveled before encountering the traps or other unknown factors.

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INTRODUCTION

The Pacific Northwest Electric Power Planning and Conservation Act of 1980 (P.L. 96-501) directed the Northwest Power Planning Council (NPPC) to develop programs to mitigate for fish and wildlife losses on the Columbia River system resulting from hydroelectric projects. Section 4(h) of the Act explicitly gives the Bonneville Power Administration (BPA) the authority and responsibility to use its resources "to protect, mitigate, and enhance fish and wildlife to the extent affected by the development and operation of any hydroelectric project on the Columbia River system."

Water storage and regulation for hydroelectric generation severely reduces flows necessary for downstream smolt migration. In response to the fishery agencies and Indian tribes recommendations for migration flows, the NPPC Columbia River Basin Fish and Wildlife Program proposed a "Water Budget" for augmenting spring flows.

The NPPC's water budget in the Columbia's Snake River tributary is 1.19 million acre-feet of stored water for use between April 15 and June 15 to enhance the smolt migration. This is the first year since the establishment of the water budget that over a million acre-feet of water were made available. In the past, only about a third of the requested 1.19 million acre-feet has been provided.

To provide information to the Fish Passage Center (FPC) on smolt movement prior to arrival at the lower Snake River reservoirs, the Idaho Department of Fish and Game (IDFG) monitors the daily passage of smolts at the head of Lower Granite Reservoir. This information allows the FPC to request the limited Snake River water budget for optimal use to provide improved passage and migration conditions.

Smolt monitoring is beneficial for water budget management under all flow conditions and becomes critical when low flow conditions reduce migration rates. In years of low flow (drought years), knowledge of when most smolts have left tributaries and entered areas that can be affected by releases of stored water allows managers to make the most timely use of the limited water budget resource. Four low flow years (1987, 1988, 1990, and 1991) have occurred during this smolt monitoring project. The indications are that judicious use of the water budget can greatly enhance the timing and migration rate of juvenile chinook salmon and steelhead trout.

Additionally, the IDFG smolt monitoring project collects other useful data on relative species composition, hatchery steelhead trout vs. wild (natural) steelhead trout ratios, travel time, and migration rate. All age 0 chinook are PIT-tagged to determine migration rate through Lower Granite Reservoir and minimum survival. All wild steelhead trout smolts are PIT-tagged to determine timing of wild adult steelhead trout one and two years later as they return to spawn. By monitoring smolt passage at the head of Lower Granite Reservoir and at Lower Granite Dam, migration rates (km/d) under various riverine and reservoir conditions can be estimated and compared. Monitoring sites, on both the Snake and Clearwater arms of Lower Granite Reservoir, permit migration timing to be determined for smolts from each drainage. Although not yet achieved, relative abundance of hatchery and wild stocks of steelhead trout can be determined and used to document wild stock rebuilding progress. The Smolt Monitoring Program's information is complementary of other Snake River and Columbia River NPPC-supported projects.

OBJECTIVES

1. Provide daily trap catch data at the head of Lower Granite Reservoir for water budget and fish transportation management purposes.

2. Determine riverine travel time from the point of release to the smolt traps (index sites) at the upper end of Lower Granite Reservoir for freeze brand and Passive Integrated Transponder (PIT) tagged smolts.

3. Provide an interrogation site for PIT-tagged smolts, marked on other projects, at the end of their migration in a riverine environment and the beginning of their migration in a reservoir environment.

4. Determine reservoir travel time for spring/summer chinook salmon, age 0 chinook salmon, hatchery steelhead trout, and wild steelhead trout from the head of Lower Granite Reservoir to Lower Granite Dam and to Little Goose Dam using PIT-tagged smolts marked at the traps and PIT-tagged smolts passing the traps from upriver hatchery releases and rearing areas.

5. Determine minimum survival during the spring outmigration period for PIT-tagged spring/summer and age 0 chinook salmon, hatchery, and wild steelhead trout in Lower Granite Reservoir.

6. Correlate smolt migration rate with river flow for fish moving in riverine and reservoir environments.

7. Determine trap efficiency for each species at each trap over a range of discharges.

8. Test the new screw trap to determine effectiveness of the trap to collect age 0 chinook salmon smolts.

9. PIT tag all age 0 chinook collected in the Snake River trap and screw trap and determine travel time and minimum survival to Lower Granite and Little Goose dams.

10. Evaluate timing of returning adult wild and natural steelhead crossing Lower Granite Dam.

METHODS

Releases of Hatchery-Produced Smolts

Release information was reported for hatcheries in the Snake River drainage upstream of Lower Granite Dam that released chinook salmon and steelhead trout juveniles which may have contributed to the 1991 outmigration. This information included species, number released, date and location released, and the group-identifying freeze brand, if used.

Smolt Monitoring Traps

During the 1991 outmigration, two smolt monitoring traps were employed to monitor the passage of juvenile chinook salmon and steelhead trout. A scoop trap (Raymond and Collins 1974) was stationed on the Clearwater River and a dipper trap (Mason 1966) was located on the Snake River (Figure 1). A third trap, a screw trap, was installed on July 2 to increase the collection of summer-migrating age 0 chinook. Smolts were captured and removed daily from the traps for examination, enumeration, and released back to the river. Fork length of up to 100 smolts for each species was measured to the nearest millimeter and up to 2,000 fish were examined for hatchery brands. Smolts were anesthetized before handling with tricaine methanesulfonate (MS-222). These fish were allowed to recover from the anesthesia before being returned to the river.

At each trap, water temperature (C) and turbidity were recorded daily using a centigrade thermometer and 20 cm secchi disk. The U.S. Weather Service provided daily information on river discharge (cfs). The Snake River trap discharge was measured at the U.S. Geological Survey (USGS) Anatone gauge (#13334300), 44.4 km upstream from the trap. The Clearwater River trap discharge was measured at the USGS Spalding gauge (#13342500), 8.8 km upstream from the trap.

Snake River Traps

The Snake River migrant dipper trap was positioned approximately 40 m downstream from the Interstate Bridge, between Lewiston, Idaho and Clarkston, Washington, and was attached to bridge piers just east of the draw bridge span by steel cables. This location is at the head of Lower Granite Reservoir, 0.5 km upstream from the convergence of the Snake and Clearwater arms. River width and depth at this location are approximately 260 m and 12 m, respectively.

A new screw trap was added to the Snake River trap location. It was attached to the Interstate Bridge but was attached to bridge piers just west of the draw bridge span.

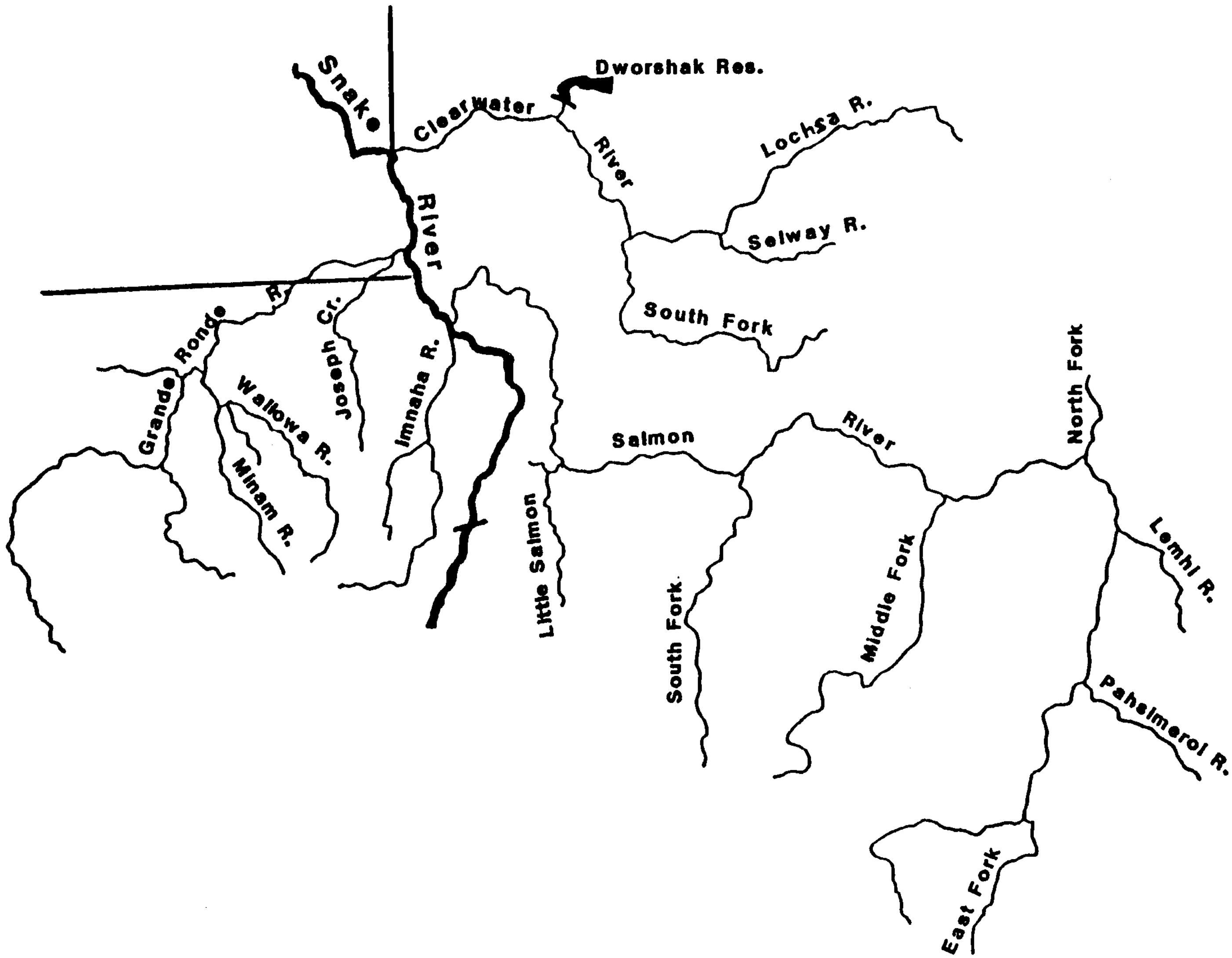

Figure 1. Map of study area.

A juvenile steelhead trout radio tracking study was conducted in 1987 (Liscom and Bartlett 1988). The study showed that during 1987, 7% of the radio-tagged steelhead trout passed the bridge under the span west of the drawbridge, where the trap was positioned, and 30% passed the bridge under the span immediately east of the drawbridge span. Because at least four times more fish were moving under the span of the bridge just east of the drawbridge, the dipper trap was moved to that location on April 27, 1988, after completing installation of an electrical line to the new trap location.

Dipper trap operation in 1991 began March 11 and continued until August 12. There were two major interruptions in trap operation, one due to an extremely heavy debris load from May 20-22 and one due to a mechanical breakdown from June 8-11. There were also 12 times when the trap did not function properly due to a heavy debris build-up in the trap or when the shear pin broke on the dipper pan. The trap was out of operation for less than 15 h on each occasion. There was one occasion when the trap was shut down from 0100-0300 h on May 10 because too many fish were entering the trap and we could not remove them from the live well fast enough.

The screw trap operation began on July 2 and continued until August 9. There was no downtime during the operation season although velocities were so low late in the season that the screw did not turn continuously.

Chinook salmon and steelhead trout smolts were tagged with PIT tags (Prentice et al. 1987) at the Snake River trap to estimate travel time from the head of Lower Granite Reservoir to Lower Granite Dam. Up to 150 chinook salmon, 60 hatchery steelhead trout, all wild steelhead trout, and all age 0 chinook were PIT-tagged daily, when available. Median travel time of the daily PIT-tagged release groups was converted to migration rate. This was correlated with mean Lower Granite Reservoir inflow for the median travel time to determine how changes in discharge affected smolt migration rate through Lower Granite Reservoir.

All fish captured in the Snake River dipper trap were passively interrogated for PIT tags as they entered the live well. All fish captured in the screw trap were interrogated when they were examined. The recovery and tagging information was sent to the PTAGIS Data Center (managed by Pacific States Marine Fisheries Commission) daily.

The PIT tag interrogation system on the Snake River trap consists of an 8-inch PVC pipe with two interrogation coils (D-4 and D-6). Each coil is connected to an exciter card and a PIT tag reader. The system does not have the capability to provide exact time of capture. Since it is checked once daily, the interrogation time is set to 00:00 h.

Coil efficiency tests were conducted on the dipper trap interrogation system. One thousand test tags were sent through the system and the reading efficiency was 98.5% for both coils, combined.

Table 1. River mite & kilometer locations for the Snake River drainage.

	Mouth of Columbia R.		Mouth of Snake River		Lower Granite Dam		Snake River trap site		Clearwater R. trap site		Salmon River trap site	
	mi	km	mi	km	mi	km	mi	km	mi	km	mi	km
Mouth of Snake River	324.3	521.8	0.0	0.0	107.5	172.9	139.6	224.6	145.7	234.5	241.4	388.4
Lower Granite Dam	431.8	694.8	107.5	173.0	0.0	0.0	32.1	51.6	38.3	61.5	133.9	215.4
Clearwater R. trap site	470.0	756.2	145.7	234.4	38.2	61.5		--	0.0	0.0		--
Highway 95 Boat Launch	473.2	761.4	148.9	239.6	41.5	66.8			3.2	5.1		
Dworshak NFH	504.3	811.4	180.0	289.6	72.5	116.6			34.3	55.2		
Kooskia NFH	541.6	871.4	217.3	349.6	109.8	176.7			71.5	115.0		
Crooked River	604.3	972.3	280.0	450.5	172.5	277.6			134.3	216.0		
Red River Rearing Pond	618.0	994.4	293.7	472.6	186.2	299.6	--	--	148.0	238.1	--	--
Snake River trap site	463.9	746.4	139.6	224.6	32.1	51.6	0.0	0.0	--	--	101.8	163.8
Asotin Creek Rel. Site	470.3	756.7	146.0	234.9	38.5	61.9	6.4	10.3			--	--
Mouth of Grande Ronde R.	493.0	793.2	168.7	271.4	61.2	98.5	29.1	46.8				
Deer Creek	504.3	811.4	180.0	289.6	72.5	116.7	40.4	65.0				
Cottonwood Creek	521.7	839.4	197.4	317.6	89.9	144.6	57.8	93.0				
Wildcat Creek	546.2	878.8	221.9	357.0	114.4	184.3	82.3	132.4	--			--
Lookingglass Creek	580.4	933.9	256.1	412.1	148.6	239.1	116.5	187.4				
Big Canyon Creek	585.9	942.7	261.6	420.9	154.1	247.9	122.0	196.3				
Spring Creek	614.4	988.6	290.1	466.8	182.6	293.8	150.5	242.2				
Catherine Creek	636.9	1024.8	312.6	503.0	205.1	330.0	173.0	278.4			--	-
Mouth of Salmon River	512.5	824.6	188.2	302.8	80.7	129.8	48.6	78.2			53.2	85.6
Imnaha River	516.0	830.3	191.7	309.1	84.2	135.7	52.1	83.8			--	--
Little Sheep Creek	553.8	891.1	229.5	369.3	122.0	196.3	89.9	144.6				
Imnaha Coll. Facility	565.6	910.2	241.3	388.3	133.8	215.4	101.7	163.6				
Hells Canyon Dam	571.3	919.2	247.0	397.4	139.5	224.5	107.4	172.8			--	--
Salmon River trap site	565.7	910.2	241.4	388.4	133.9	215.4	101.8	163.8			0.0	0.0
Rapid River Hatchery	605.8	974.7	281.5	452.9	174.0	280.0	141.9	228.3			40.1	64.5
Hazard Creek	618.7	995.5	294.4	473.7	186.9	300.7	154.8	249.1			53.0	85.3
S.F. Salmon @ Knox Bridge	719.7	1158.0	395.4	636.2	287.9	463.2	255.8	411.6			154.0	247.8
Pahsimeroi Hatchery	817.5	1315.4	493.2	793.6	385.7	620.6	353.6	568.9			251.8	405.1
E.F. Salmon @ trap site	873.6	1405.6	549.3	883.8	441.8	710.9	409.7	659.2			307.9	495.4
Sawtooth Hatchery	896.7	1444.2	573.3	922.4	465.8	749.5	433.7	697.8			331.9	534.0

Clearwater River Trap

The Clearwater River scoop trap was installed 10 km upstream from the convergence of the Clearwater River and Snake River arms of Lower Granite Reservoir (4.5 km upstream from slack water). The river channel at this location forms a bend and is 150 to 200 m wide and 4 m to 7 m deep, depending on discharge.

Trap operation began March 13 and continued until May 12. Trapping was discontinued because of high discharge and/or debris for four d this season, April 26-30.

Chinook salmon and steelhead trout smolts were tagged with PIT tags at the Clearwater River trap to estimate travel time from the head of Lower Granite Reservoir to Lower Granite Dam for Clearwater River fish. Up to 150 chinook salmon, 60 hatchery steelhead trout, and all wild steelhead trout were PIT-tagged daily, when available. Median travel time of the daily PIT-tagged release groups was converted to migration rate. This was correlated with mean Lower Granite Reservoir inflow for the median travel time to determine how changes in discharge affected smolt migration rate through Lower Granite Reservoir.

All fish were interrogated for PIT tags as the fish were removed from the live well. The tagging and interrogation files were sent to the PTAGIS Data Center daily.

The PIT tag interrogation system on the Clearwater River trap consists of a 4-inch PVC pipe with two interrogation coils (D-0 and D-2). Each coil is attached to an exciter card and a PIT tag reader. This system is battery operated. The system was tested by passing 1,543 test tags through the system. The efficiency for both coils was 98.8%, combined.

Trap Efficiency

The proportion of the migration run being sampled is termed trapping efficiency. Since trap efficiency may change as river discharge changes, efficiency has been estimated several times through the range of discharge at which the trap was operated. A linear regression equation (Ott 1977) describing the relation of trap efficiency and discharge was derived to estimate efficiency at any given discharge.

During the 1991 trap operations, no trap efficiency tests were conducted at either of the traps. Yearly trap efficiency estimates are reported in Buettner and Nelson (1990).

Travel Time and Migration Rates

Migration statistics were calculated for hatchery release groups from release sites to traps. Travel time and migration rates to the traps were calculated using median arrival times at the Snake River and Clearwater River traps. Median arrival (or passage) date is the sample date the 50th percentile fish arrived at the trap or collection facility. Smolts were PIT-tagged at the Snake River and Clearwater River traps as the primary method to determine travel time from the head of Lower Granite Reservoir to Lower Granite and Little Goose dams. Distances from release point to recovery location are listed in Table 1. Daily individual arrival times of these fish at Lower Granite and Little Goose dams collection facilities were determined. A minimum recapture number, sufficient for use in travel time and migration rate estimations, was derived from an empirical distribution function of the travel time for each individual release group (Steinhorst et al. 1988). If recapture numbers were less than five or less than the number derived from the empirical distribution function, the daily data were combined with another day's data or the data were not used. If it was combined, it was added to daily data from an adjacent release day that had similar discharge and travel time.

Smolt migration rate/discharge relations through Lower Granite Reservoir were investigated using linear regression analysis after both variables were log (In) transformed (Zar 1984). The 0.05 level was used to determine significance. This analysis was performed for the hatchery freeze-branded chinook salmon and steelhead trout groups and for the PIT-tagged spring/summer chinook salmon, age 0 chinook salmon, hatchery steelhead trout and wild steelhead trout groups marked at the Snake River or Clearwater River traps.

To remove some of the "noise" often associated with biological data and better show the underlying biological relation, migration rate was stratified into 5-kcfs discharge intervals (Mosteller and Tukey 1977). A linear regression analysis was conducted on the grouped data.

A linear regression analysis was performed on the migration rate/discharge data for PIT-tagged fish released from the Snake River and Clearwater River traps and interrogated at Little Goose Dam. Data that had been stratified into 5-kcfs discharge intervals and log transformed were used in the analysis.

The migration rate/discharge relations, for PIT-tagged chinook salmon, hatchery steelhead trout, and wild steelhead trout were individually examined for 1987-1991 to determine if the relations were different between years. Using an analysis of covariance, with the migration rate data stratified by 5-kcfs groups, the first underlying assumption of equality of slopes was tested. If the hypothesis of equality of migration rate/discharge slopes among years was not rejected, then the subsequent analysis of covariance was completed. This was basically a test of whether the regression lines relating migration rate and discharge for each year had a common intercept, or whether one regression line was higher than another. If the final hypothesis of common intercepts was not rejected, there was not a significant difference in the migration rate/discharge relations among years, and the yearly data were pooled. After pooling, a linear regression analysis was run to provide the best fitting equation to describe the relation between migration rate and discharge for an individual species over several years.

Minimum Survival of PIT-Tagged Fish

Estimates of minimum survival of PIT-tagged fish, marked at the head of Lower Granite Reservoir, to Lower Granite Dam collection facility included data from 1988-1991 for the Snake River trap and 1989-1991 for the Clearwater River trap. Using both chinook salmon and steelhead trout smolts marked throughout the sampling season, a "Minimum Survival Estimate" from the trap to Lower Granite Dam was derived. This minimum estimate consists of fish that were interrogated at Lower Granite, Little Goose, or McNary dams. The data have been examined to ensure that multiple interrogations within a dam and between dams have been removed. The basis for the minimum survival estimate at Lower Granite Dam is that fish that were interrogated at Lower Granite, Little Goose, or McNary dams were alive when they passed Lower Granite Dam. This estimate is held to be a "minimum" estimate because there are fish that passed all three dams without being detected and due to mortality that occurs downstream of Lower Granite Dam.

RESULTS AND DISCUSSION

Hatchery Releases

Chinook Salmon

Chinook salmon released into the Snake River drainage upstream from Lower Granite Dam were reared at nine locations in Idaho and two in Oregon. The Washington Department of Fisheries released no chinook salmon juveniles in the Snake River drainage upstream from Lower Granite Dam that contributed to the 1991 outmigration. A total of 9,645,205 chinook salmon smolts were released at 16 locations in Idaho and two locations in Oregon (Table 2).

During the late summer and fall of 1990, four groups of chinook salmon juveniles were released from Idaho hatcheries. All other chinook salmon releases for the 1991 outmigration were made in the spring of 1991 (Table 2).

Steelhead Trout

Steelhead trout were reared at four locations in Idaho, one in Washington, and two in Oregon for release into the Snake River drainage upstream from Lower Granite Dam. A total of 9,893,980 steelhead trout smolts were released at 16 locations in Idaho, nine locations in Oregon, and one location in Washington

Table 2. Hatchery chinook salmon released into the Snake River system upriver from Lower Granite Dam contributing to the 1991 outmigration.

Release site (hatchery)	Stock	Release date	No. released (No. branded)	Brand
Salmon River				
East Fork Salmon River (Sawtooth)	Spring	3/5	98,300	
Little Salmon River at Hazard Creek (Rapid River)	Spring	3/21	100,100	
Salmon River at Hell Roaring Creek Bridge (Sawtooth)	Spring	8/16/90	2,000	
South Fork Salmon River (McCall)	Spring	3/18-21	708,600	
		(3/20)	(20,122)	RD>0-1
		(3/20)	(22,608)	RA>0-1
		(3/20)	(20,097)	LA>0-1
Pahsimeroi River (Pahsimeroi)	Spring	3/13-22	227,500	
Rapid River (Rapid River)	Spring	3/15-4/5	2,564,900	
		(3/28)	(20,417)	RA>1-1
		(3/28)	(21,398)	RD>1-1
		(3/28)	(19,871)	RD>1-3
Salmon River at Sawtooth Weir (Sawtooth)	Spring	3/8-3/13	650,600	
		(3/13)	(18,190)	LA>1-1
		(3/13)	(19,238)	LD>1-1
		(3/13)	(17,696)	LD>1-3
Yankee Fork (Sawtooth)	Spring	10/10/90	491,290	
	Drainage Total		**4,843,290**	
Snake River and Non-Idaho Tributaries				
Hells Canyon Dam (Rapid River)	Spring	3/19-22	500,500	
Imnaha River (Imnaha)	Spring	3/22	267,670	
		(3/22)	(20,441)	RDJ-2
		(3/22)	(20,676)	LDJ-2
		(3/22)	(20,668)	RDJ-4
		(3/22)	(20,777)	LDJ-4
		4/9	131,239	

Table 2. Continued.

Release site (hatchery)	Stock	Release date	No. released (No.branded)	Brand
Lookingglass Creek	Spring	4/1	331,636	
(Lookingglass)		(4/1)	(20,799)	RDJ-1
		(4/1)	(20,819)	LDJ-1
		(4/1)	(22,083)	RDJ-3
		(4/1)	(19,375)	LDJ-3
		4/2	504,668	
		6/13	17,404	
	Drainage Total		**1,753,117**	
Clearwater River				
Clear Creek (Kooskia)	Spring	4/16	396,619	
Crooked River (Crooked River)	Spring	10/17/90	339,100	
Eldorado Creek (Dworshak)	Spring	3/25-26	199,456	
N.F. Clearwater	Spring	4/3	1,094,884	
(Dworshak)		(4/3)	(19,704)	RDIK-1
		(4/3)	(16,884)	RAIK-1
Papoose Creek (Dworshak)	Spring	3/25-26	70,000	
Red River				
(Dworshak)	Spring	3/25	63,004	
(Kooskia)	Spring	3/27	124,071	
(Red River)	Spring	10/23/90	273,800	
Powell				
(Kooskia)	Spring	3/12-4/1	180,764	
(Powell)	Spring	10/23/90	307,100	
	Drainage Total		**3,048,79**	
	Grand Total		**9,645,20**	

(Table 3). Fall releases of steelhead trout juveniles have not been included in this total.

Smolt Monitoring Traps

Snake River Trap Operation

The Snake River trap caught 3,834 age 1 chinook salmon, 95 age 0 chinook salmon, 19,020 hatchery steelhead trout, 4,136 wild steelhead trout, and 801 sockeye/kokanee salmon *Oncorhynchus nerka*. Chinook salmon catch at the Snake River trap for 1991 was similar to other low flow years (1987, 1988, and 1990) and considerably lower than 1984-1986 or 1989, normal or above normal flow years. There appears to be a threshold velocity required within the trap to collect chinook salmon effectively. Below this threshold velocity, which is about 1.6 to 1.8 ft/s, trap efficiency is very low and chinook salmon trap catch may not be representative of the chinook salmon population passing the trap. The threshold velocity is generally exceeded when discharge **is** above 27,000 to 33,000 cfs. The outmigration pattern was similar to other years (Figure 2).

This was the first year that physical characteristics were used to differentiate between age 0 chinook salmon and other chinook salmon. The peak movement of age 0 chinook salmon was during mid-June. Age 0 chinook catch in the Snake River trap had virtually stopped by July 14. The lack of age 0 chinook salmon in the Snake River trap catch was due to either a lack of fish movement or to low velocities in the trap reducing trap efficiency.

There were three major peaks in hatchery steelhead trout passage. The first began **in** late April and lasted until the end of the month (Figure 3). The second began on May 7 and lasted until May 14. This period had the highest daily catch for the season of 3,122 smolts which occurred on May 10. This daily peak was the highest ever encountered at the Snake River trap and was two times greater than the highest ever previous daily catch of hatchery steelhead trout. The trap was also out of operation for three h during this night (0001-0300 h), because fish were coming into the trap faster than we could work them up. The third peak began on May 18 and lasted until May 26. During this period the trap was out of operation for three days (May 20-22) due to an extremely heavy debris load.

Twelve percent of the hatchery steelhead trout were captured in April, 85% in May, and 3% in June, 1991 The early portion of the run was shifted from late April to early May probably due to a late runoff in the Salmon River drainage. Generally, wild steelhead trout passage is earlier than hatchery steelhead trout, but this year they migrated out of the system at the same time. Eleven percent of the wild steelhead trout were captured in April, 88% in May, and 1% in June (Figure 3). Similar to the hatchery steelhead trout timing, the wild steelhead trout timing was delayed due to the late spring runoff in the Salmon River drainage.

Table 3. Hatchery steelhead trout released into the Snake River system upriver from Lower Granite Dam contributing to the 1991 outmigration.

Release site (hatchery)	Stock	Release date	No. released (No.branded)	Brand
Salmon River				
East Fork Salmon River (Magic Valley)	B	4/13	967,800	
Salmon River at Ellis Bridge (Niagara Springs)	A	4/15-17	174,400	
Salmon River at Hammer Creek (Magic Valley)	A	4/22-25	186,300	
Little River Hazard Creek (Hagerman)	B	4/17-29	457,110	
(Magic Valley)	A	4/26	310,300	
Salmon River at North Fork (Niagara Springs	A	4/19-22	158,400	
Pahsimeroi River (Niagara Springs)	A	4/9-14	475,000	
(Magic Valley)	A	4/18-19	135,100	
Salmon River at Sawtooth Hatchery (Hagerman)	A	4/3-16	979,799	
(Magic Valley)	A	4/9-19	364,700	
Salmon River at Shoup Bridge (Niagara Springs)	A	4/18	48,200	
(Magic Valley)	A	4/20-21	97,800	
	Drainage Total		**4,354,909**	
Snake River and Non-Idaho Tributaries				
Big Canyon Pond (Irrigon)	A	4/26-5/6	47,187	
Catherine Creek (Irrigon)	A	4/11-16	111,464	
Deer Creek (Irrigon)	A	4/26	271,980	
		4/26	(20,654)	RAJ-2
		4/26	(20,946)	LAJ-2
		4/26	(20,289)	RAJ-4
		4/26	(20,798)	LAJ-4

Table 3. Continued

Release site (hatchery)	Stock	Release date	No. released (No.branded)	Brand
Grande Ronde R-2 above La Grande, OR (Irrigon)	A	4/8-11	200,466	
Grande Ronde River km 41 (Lyons Ferry)	A	4/16-30	252,799	
Grande Ronde River km 67 (Lyons Ferry)	A	4/30	52,500	
Hells Canyon Dam (Niagara Springs)	A	4/22-5/2	912,000	
Imnaha River (Irrigon)	A	5/1-5/3	86,235	
Little Sheep Creek (Irrigon)	A	4/23	242,982	
		4/23	(19,953)	RAA-3
		4/23	(20,499)	LAA-3
		4/23	(20,000)	RAA-1
		4/23	(19,890)	LAA-1
Spring Creek (Wallowa)	A	4/22	497,148	
		4/22	(20,161)	RAJ-1
		4/22	(20,777)	LAJ-1
		4/22	(20,100)	RAJ-3
		4/22	(20,989)	LAJ-3
	A	5/2	109,529	
Wildcat Creek (Irrigon)	A	4/30	98,783	
		4/30	(27,055)	RAA-2
		4/30	(26,124)	LAA-2
	Drainage Total		**2,883,073**	
Clearwater River				
American River (Dworshak)	B	4/15-24	210,874	
Clear Creek (Dworshak)	B	4/15-24	369,190	
Clearwater River at DNFH (Dworshak)	B	4/29-5/1	1,192,503	
		(4/29-5/1)	(4,603)	LA7U-1
		(4/29-5/1)	(14,698)	RD7U-1
		(4/29-5/1)	(5,280)	LD7U-1
		(4/29-5/1)	(14,015)	RA7U-1
		(4/29-5/1)	(4,864)	LA7U-3
		(4/29-5/1)	(9,361)	RD7U-3
		(4/29-5/1)	(4,740)	LD7U-3

Table 3. Continued

Release site (hatchery)	Stock	Release date	**No. released** (No.branded)	Brand
Eldorado Creek (Dworshak)	B	4/15-26	201,847	
S.F. Clearwater R. at Mill Creek Bridge (Dworshak)	B	4/15-24	290,421	
S.F. Clearwater R. at Mount Idaho Bridge (Dworshak)	B	4/15-24	177,336	
Red River (Dworshak)	B	4/15-24	213,827	
	Drainage Total		**2,655,998**	
	Grand Total		**9,893,980**	

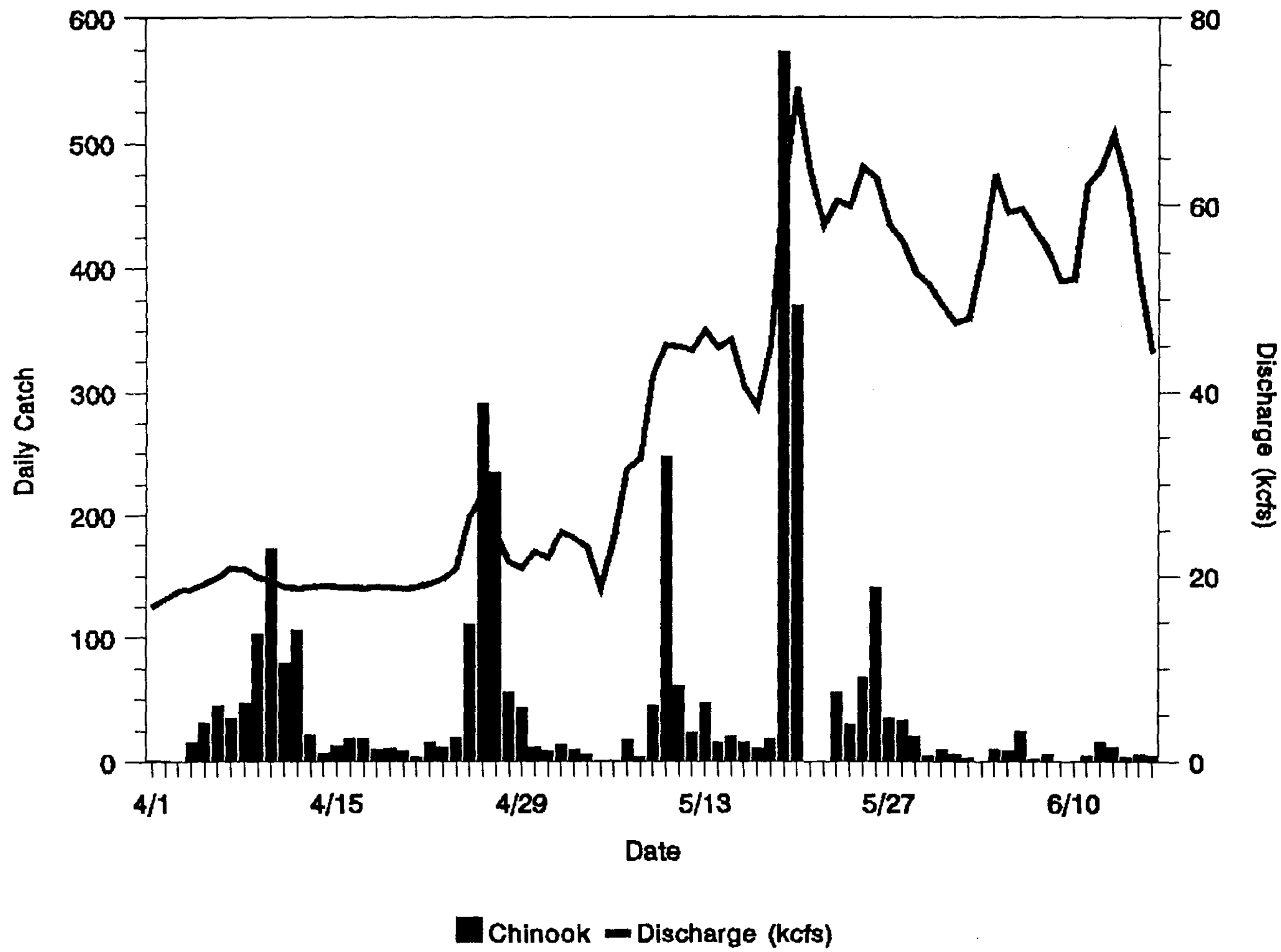

Figure 2. Snake River trap daily catch of age 1 chinook salmon overlaid by the Snake River discharge, 1991.

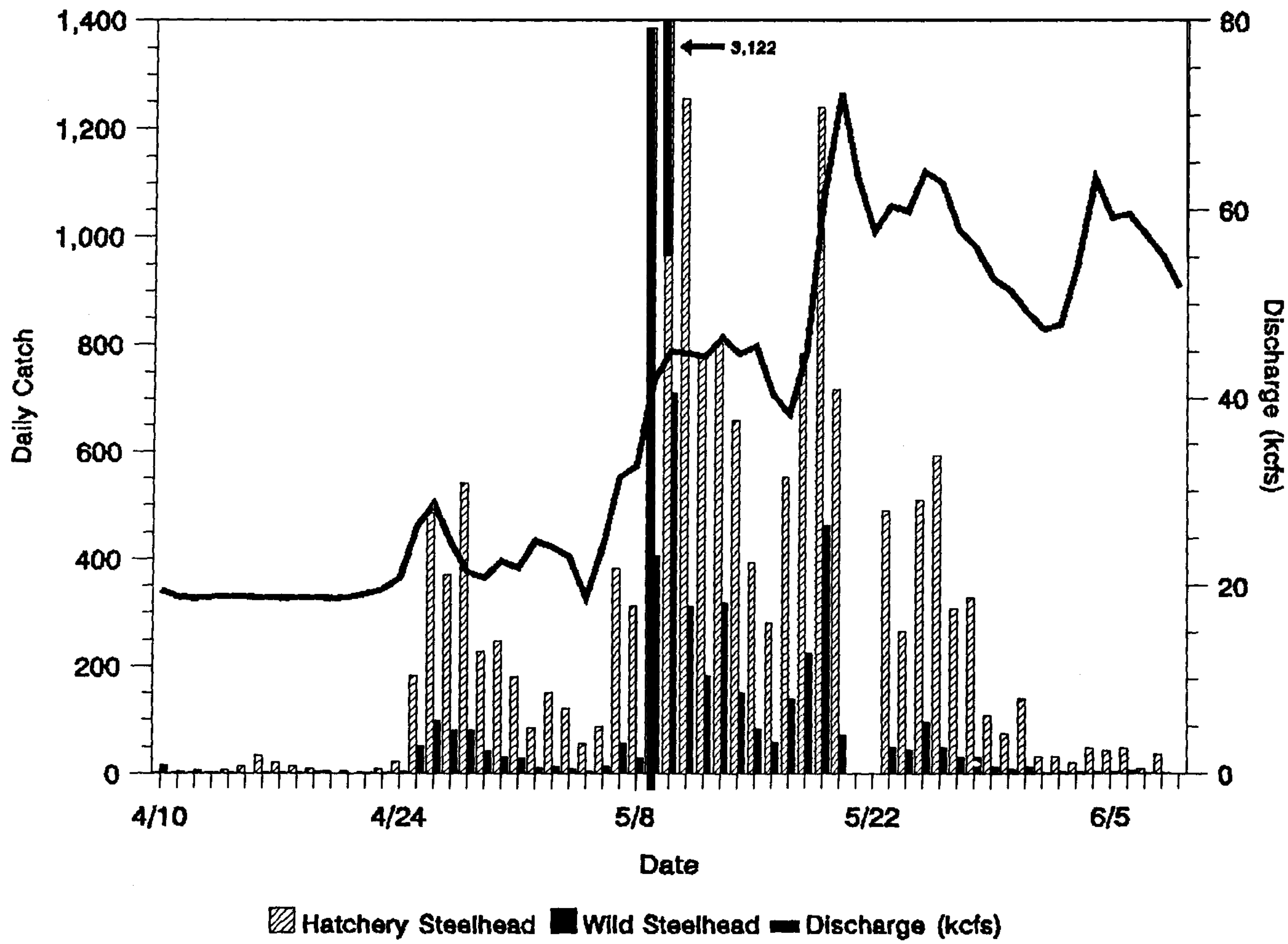

Figure 3. Snake River trap daily catch of hatchery steelhead trout and wild steelhead trout overlaid by Snake River discharge, 1991.

The Snake River trap catch for wild steelhead trout was 1.2 times greater than in any previous year, The daily trap catch of 711 fish on May 10 was more than two times greater than any previous day. The Snake River trap was out of operation from 0001-0300 h that day because fish were coming into the trap faster than we could remove them. This reflects a similar outmigration in wild steelhead trout to 1990 which was greater than in previous years. Wild steelhead trout had three major periods of movement. These coincided with the three major periods of movement for hatchery steelhead trout (Figure 3). Each major period of movement was associated with a substantial increase in Snake River discharge.

Snake River discharge, measured at the Anatone gauge, ranged from 16,300 cfs to 29,100 cfs and averaged 19,100 cfs in March (Figure 3), which was 5,000 cfs lower than in 1990 and 21,500 cfs lower than in 1989. The average April discharge was 20,100 cfs, with a peak of 28,800 cfs on April 26. The April average was 10,800 cfs lower than in 1990 and 38,400 cfs lower than in 1989. Flows remained below 25,000 cfs until May 7. After May 7, discharge began to increase and peaked on May 20 at 72,500 cfs for the month and for the year. The average May discharge was 45,400 cfs, which was 6,600 cfs higher than 1990 and 6,700 cfs lower than in 1989. Flows had dropped to 47,400 cfs by the first of June and began to increase again. A second peak for the season occurred on June 13 at 67,600 cfs. The average June flow was 48,500 cfs and was similar to the 1990 average June flow of 46,100 cfs. The discharge remained fairly high until July 15. After this date, it dropped rapidly to summer low flow conditions of less than 15,000 cfs.

Runoff during the 1991 outmigration season in the Snake River above the mouth of the Clearwater River was delayed in April due to a very cold spring. This increased the amount of runoff which occurred in May, June, and July. The 1991 outmigration season had the best flow conditions late in the season since the drought started in 1987.

Water temperature in the Snake River at the trap steadily increased throughout the sampling season (Figure 4). By the end of the season, August 12, water temperature had risen to 23°C. Water temperatures were similar to 1990 except for May, 1991 when water temperature was slightly lower than May, 1990.

Secchi disk transparency fluctuated throughout the sampling season (Figure 4). Influenced mainly by localized rain or thunderstorm events, secchi transparency shows no biological correlation to discharge ($r^2 = 0.130$, $N = 101$, $P<0.001$). The lowest secchi disk transparency of 0.1 m on May 19 was associated with the maximum discharge for the season.

Clearwater River Trap Operation

The Clearwater River trap caught 39,522 chinook salmon, 9,231 hatchery steelhead trout, 824 wild steelhead trout, and 44 sockeye/kokanee salmon in 1991. The chinook salmon trap catch for 1991 was about 30% less than in 1990 but three times greater than the lowest trap catch of 9,938 in 1989. The 1991 hatchery steelhead trout trap catch was equivalent to the second highest catch which

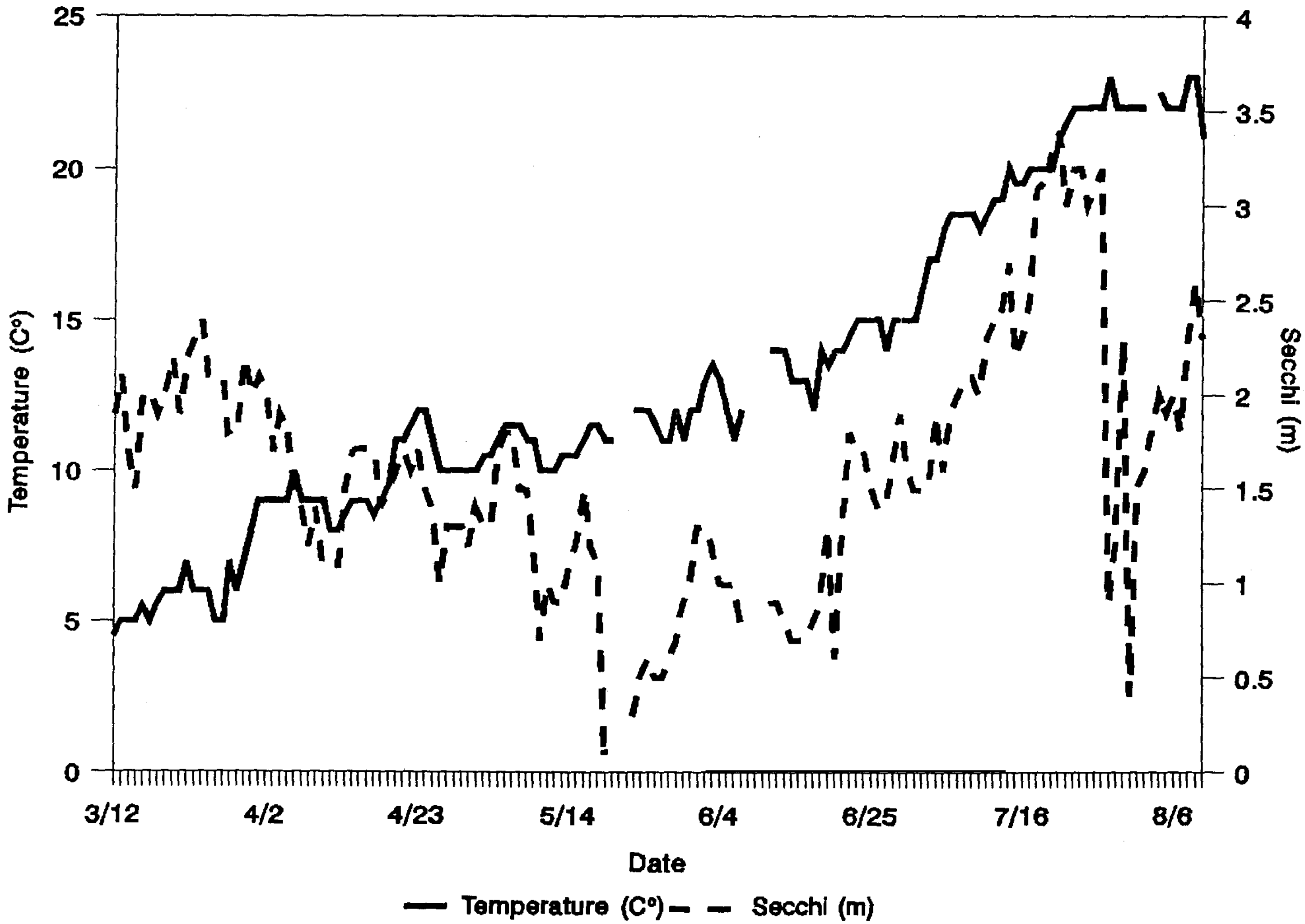

Figure 4. Daily temperature and secchi disk transparency at the Snake River trap, 1991.

occurred in 1988 but three times less than the highest which occurred in 1990. The wild steelhead trout trap catch was similar to the second highest trap catch in 1987 and about half the highest catch which occurred in 1990.

Two major peaks of chinook salmon passage were observed at the Clearwater River trap (Figure 5). The first began on April 3 and peaked on April 5. This peak was associated with chinook salmon passing the trap from Dworshak National Fish Hatchery (DNFH) releases. The second peak was on April 18 through 20 and was probably associated with the releases from Kooskia National Fish Hatchery (KNFH) and fall-released smolts from Powell, Crooked River and Red River rearing ponds. Numbers remained relatively high for several weeks after the second peak. The latter part of the outmigration was not sampled because trap operation was terminated on May 12 due to high discharge.

Hatchery steelhead trout began showing up in the trap catch in low numbers (<100 fish per day) on April 17. There was a major movement of hatchery steelhead trout prior to the DNFH release and was due to movement of smolts outplanted in the Clearwater River upstream from DNFH. The major peak, which occurred on May 2, was associated with the DNFH release (Figure 6). Overall hatchery steelhead trout capture was lower in 1991 than in 1990, because the trap was operated fewer days in the optimum position near the thalweg in 1991, and trap operation was terminated on May 12, 1991 and on May 25, 1990.

Wild steelhead trout were present in the trap catch in low numbers (one to six fish per day) from March 21 until April 6. The first of four peaks began on April 7 and lasted until April 12 (Figure 6). The second began on April 17 through April 19. The third and major peak began on April 22 and was still in progress when trap operation was interrupted on April 26 due to high flow. The last peak began on May 6 through May 11. Trap catch of wild steelhead trout in 1991 was considerably lower than in 1990. This is probably a function of trap location rather than lower number of wild steelhead trout migrating out of the system. The trap was operated fewer days in the optimum location near the thalweg in 1991 due to high flows.

Water temperature at the Clearwater River trap at the beginning of the season was 4.5°C and gradually increased to 10°C by April 23 (Figure 7). Water temperature dropped to 7°C by April 26 and then gradually climbed back to 9°C by the end of the trapping season on May 12. Water temperatures were several degrees cooler than normal throughout the season.

Secchi disk transparency in the Clearwater River fluctuated throughout the trapping season and ranged from 0.4 m to 2.6 m (Figure 7). There was a significant statistical correlation between secchi disk transparency and discharge ($r^2 = 0.171$, $N = 61$, $P = 0.001$), but the relation was weak.

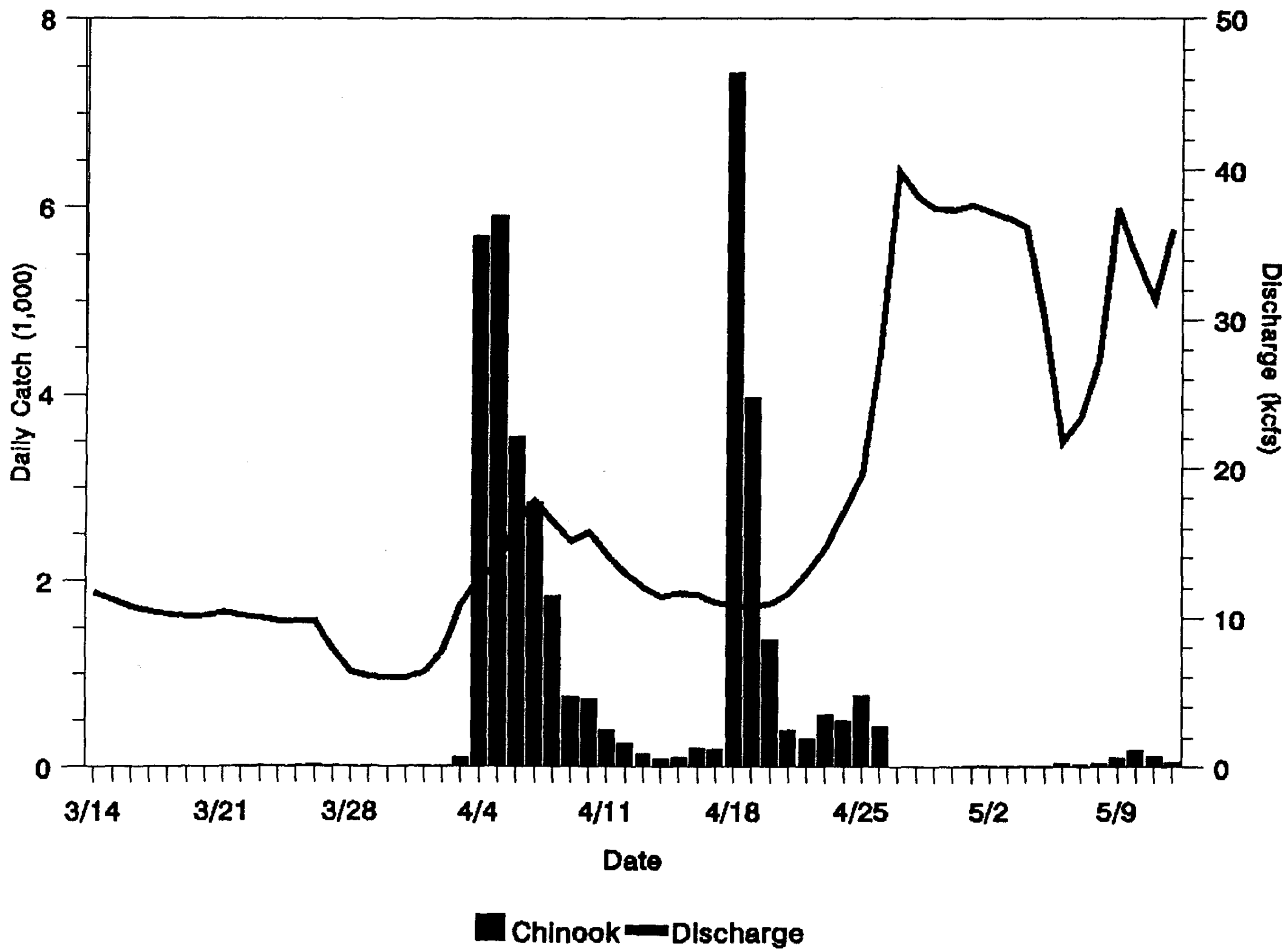

Figure 5. Clearwater River trap daily catch of age 1 chinook salmon overlaid by Clearwater River Discharge, 1991.

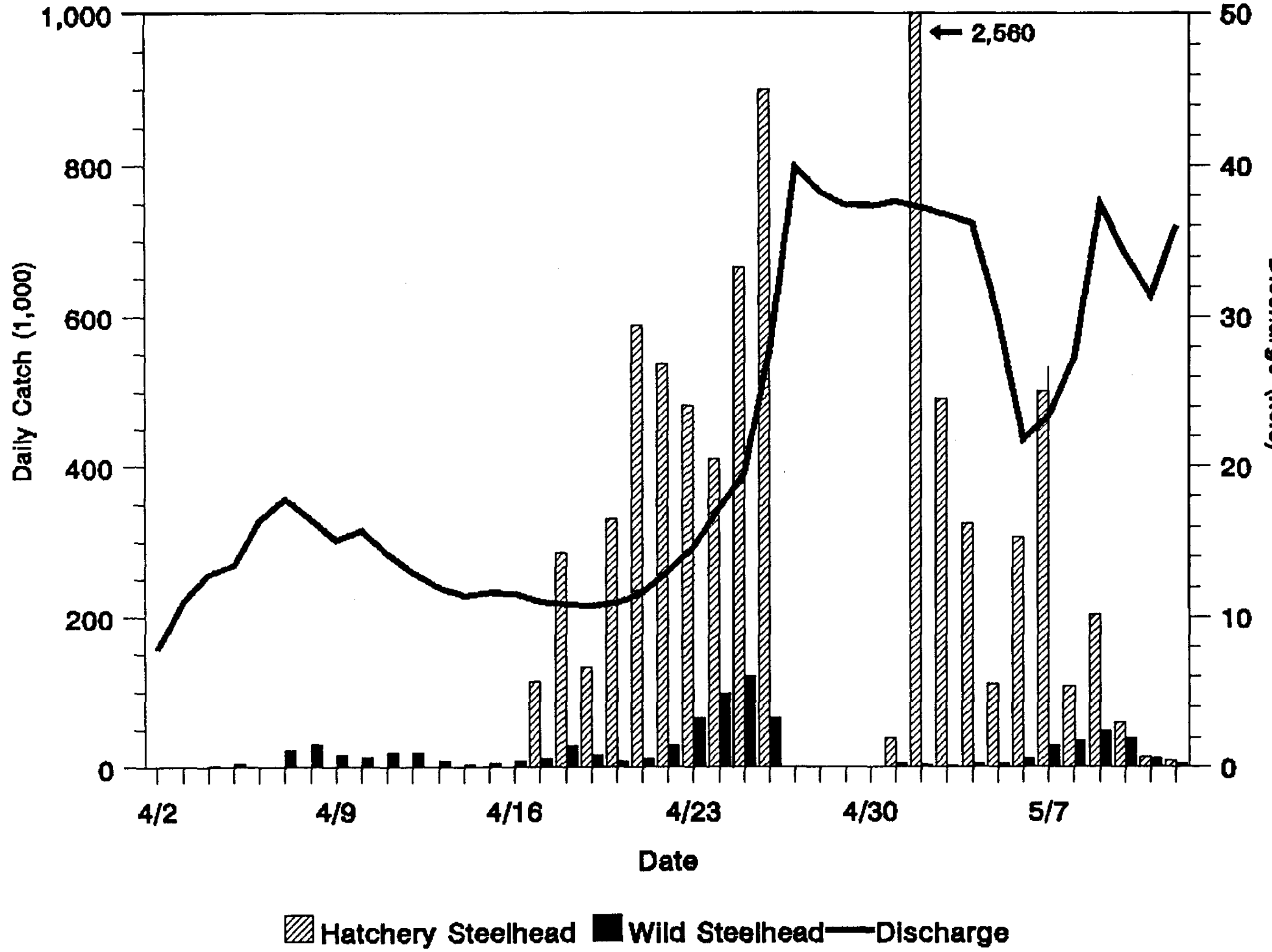

Figure 6. Clearwater River trap daily catch of hatchery steelhead trout and wild steelhead trout overlaid by Clearwater River discharge, 1991.

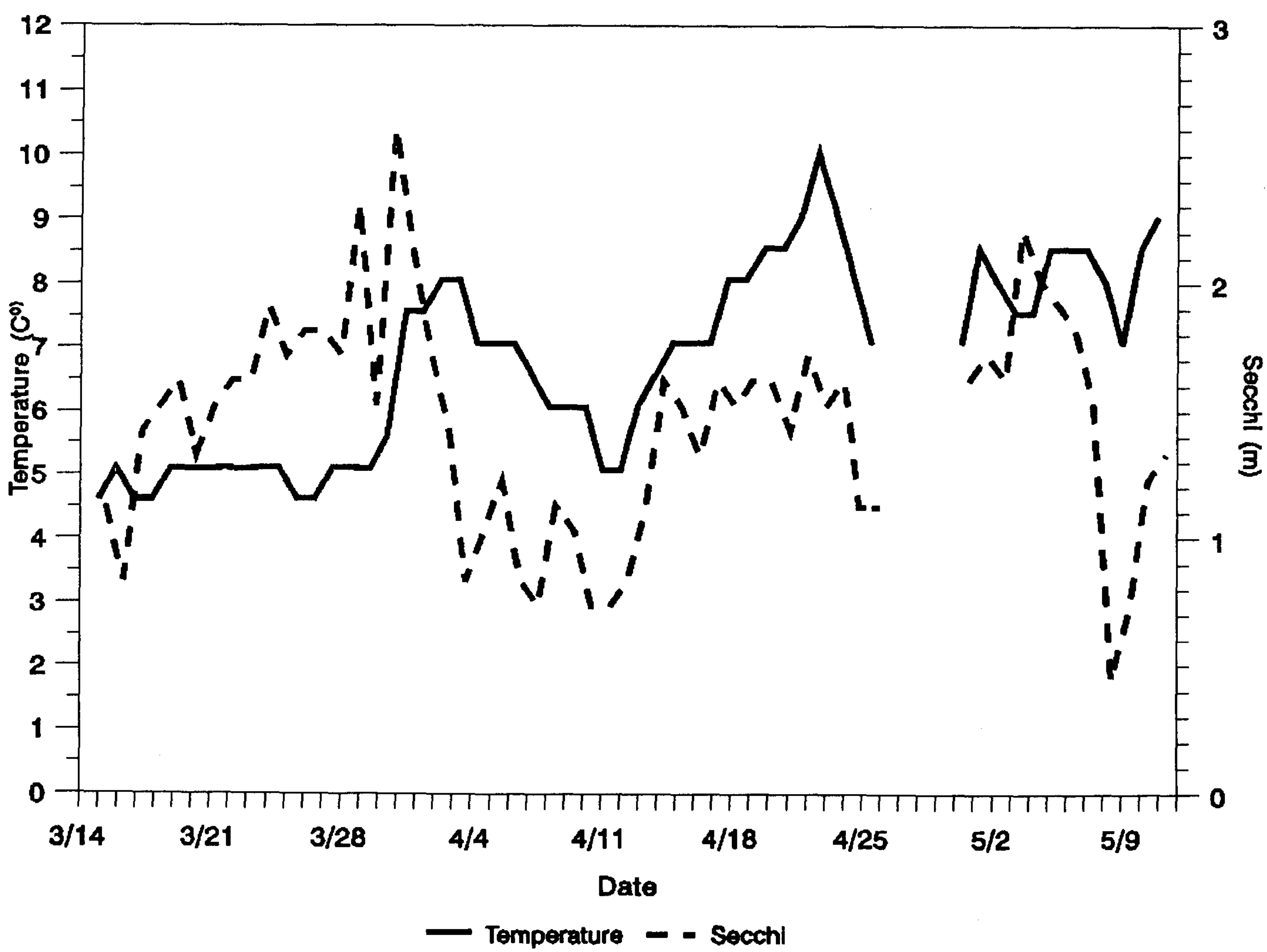

Figure 7. Daily temperature and secchi disk transparency at the Clearwater River trap, 1991.

Trap Efficiency

Snake River Trap

Chinook Salmon-Trap efficiency for chinook salmon smolts at the Snake River trap was not tested in 1991. Due to a reduced number of chinook salmon smolts in the trap, sufficient numbers of fish were not available for trap efficiency estimates. The mean trap efficiency for chinook salmon at the Snake River trap, with four yearly estimates during the past seven years, is 1.39%. All four of these estimates were made when the trap was in use on the west side of the river. Trap efficiency estimates for chinook salmon have not been conducted with the trap in use on the east side of the river.

Steelhead trout-No trap efficiency tests were conducted for steelhead trout smolts in 1991. The 1990 data yielded a mean trap efficiency of 0.49% and 95% confidence limits of 0.13% and 1.08%.

The analysis of covariance, to test if trap efficiency varies among years when adjusted for discharge, was not valid due to the limited data available in 1985 and 1986. The analysis was conducted using data from 1988-1990. No significant difference was observed for the three years of data, and the data were pooled. **A** regression analysis was conducted on the pooled data to determine if there was a relation between discharge and trap efficiency. The analysis failed to show a significant relation ($r^2 = 0.001$, $N = 10$, $P = 0.937$).

To provide a grand mean trap efficiency, all five years of data (1985, 1986, and 1988-1990) were pooled. The five-year grand mean of the Snake River trap efficiency for hatchery steelhead trout was 0.68% with a 95% confidence interval of 0.43% and 0.97%.

Clearwater River Trap

Chinook salmon-In 1991, two groups of freeze-branded chinook salmon were released from DNFH. The Clearwater River trap efficiency estimate using these two groups was 1.16% which was down from the 1990 estimate, but was within the confidence limits of the 1990 estimate. The 1990 mean trap efficiency was 1.41% with 95% confidence limits of 1.03% and 1.86%. Between 1984 and 1989, an additional 42 trap efficiency tests were conducted on the Clearwater River trap for chinook salmon smolts (Table 4). These data were not added to the previous years information for statistical analysis due to the low numbers of brand groups. The determination of the height of the line within the analysis of covariance on the 1984-1990 log transformed data revealed a significant difference in trap efficiency among years ($F = 3.666$, $N = 51$, $P = 0.005$). Upon examination of the yearly efficiency data 1989 appeared to be significantly different. The 1989 data were removed and the analysis of covariance rerun. Without the 1989 data, the slopes of the other years data were not significantly different ($F = 1.295$, $N = 42$, $P = 0.292$). Continuing with the analysis, the

Table 4. Clearwater River trap efficiency tests for chinook salmon smolts, 1984-1991.

Year	Sample Origin	Release Dates	Recaptures/ Mark	Efficiency	Discharge (kcfs)
1991	DNFH	4/3	360/19,704	0.0183	12
		4/3	204/16,884	0.0121	12
1990	Hwy 95 boat launch	3/21	27/2,609	0.0103	22
		3/26	28/2,266	0.0124	13
		3/28	37/2,195	0.0169	13
		3/30	56/2.061	0.0272	12
		4/2	33/2,136	0.0154	17
	DNFH	4/5	23/1,418	0.0162	21
		4/5	180/20.239	0.0089	21
		4/5	163/19.900	0.0082	21
		4/5	282/19,730	0.0143	21
1989	Hwy 95 boat launch	3/21	7/2,076	0.0034	17
		3/23	10/2.065	0.0048	15
		4/3	39/2.094	0.0186	20
		4/5	41/2,075	0.0200	21
	DNFH release	3/29	66/34,795	0.0019	24
		3/29	73/30.503	0.0024	24
		3/30	41/19.087	0.0021	23
		3/30	48/19.545	0.0025	23
		3/30	78/20,084	0.0039	23
1988	Hwy 95 boat launch	3/14	51/2,197	0.0232	6
		3/17	93/2.197	0.0423	6
		3/21	83/2.197	0.0378	6
		4/1	27/2.195	0.0123	9
		4/6	18/2.194	0.0082	11
		4/13	31/2,193	0.0141	14
	DNFH release	3/30	1711/60,631	0.0282	10
		3/30	252/8,731	0.0289	10
		3/30	181/6,163	0.0294	10
		3/30	788/20.642	0.0382	10
		3/30	573/22,935	0.0250	10
	Trap caught	3/24	17/2086	0.0081	9
		3/28	27/1695	0.0159	12
		4/1	16/1631	0.0098	9
		4/2	38/2257	0.0168	8
1987	DNFH release	3/20	43/2,160	0.0199	13
		4/22	50/2.000	0.0250	6
		4/7	165/1,945	0.0848	10
		4/13	74/2,000	0.0370	13
		4/20&28	103/4.000	0.0258	18

Table 4. Continued.

Year	Sample Origin	Release Dates	Recaptures/ Mark	Efficiency	Discharge (kcfs)
1987	Trap caught	4/2	33/1,926	0.0171	6
		4/3	11/1,458	0.0075	8
		4/6	15/1,872	0.0080	9
		4/7	15/1,163	0.0129	10
		4/9	9/450	0.0200	12
1986	Trap caught	3/27	9/1,555	0.0058	22
		4/2	8/1,714	0.0047	29
1985	Trap caught	3/25	14/607	0.0230	9
		3/30	45/1,511	0.0298	9
		4/5	6/1,079	0.0056	18
		4/9	2/940	0.0021	15
		4/16	7/929	0.0075	33
1984	Trap caught	4/5	4/418	0.0096	21
		4/21	13/806	0.0161	33
		4/25	3/489	0.0061	31
		5/10	14/453	0.0309	24

intercepts (height) of the lines were not found to be significantly different ($F = 1.514$, $N = 42$, $P = 0.211$). The data were pooled, and a linear regression analysis was conducted. The analysis indicated there was a significant statistical correlation between trap efficiency and discharge but only 18% of the variation in efficiency can be attributed to changes in discharge ($r^2 = 0.183$, $N = 42$, $P = 0.005$). The mean chinook salmon trap efficiency for the pooled data, excluding 1989 and 1991, was 2.02% with 95% confidence limits of ±0.43%. The mean trap efficiency for 1989 was 1.04%, which was considerable lower than that of the pooled years but similar to the 1991 estimate (1.16%).

The trap efficiency during the first portion of the season was probably similar to the 1989 efficiency which would account for the low numbers of fish captured from the DNFH release. Trap efficiency probably improved after mid-April which is reflected in large trap catches from the KNFH release and the off-site releases. The cause of the low trap efficiency during the first portion of the sample season is unknown. A similar phenomenon occurred in 1989 and 1990.

Steelhead trout-No trap efficiency tests were conducted in 1991. The 1990 mean trap efficiency was 1.90% with 95% confidence limits of 1.42% and 2.46%. This is the highest trap efficiency observed for the Clearwater trap. One possible explanation for this increased efficiency is the trap was in an ideal fishing location, with respect to water conditions, during the test period. This type of positioning is difficult to maintain throughout a sampling season, because such fast water passes through the trap that slight increases in discharge or debris load could be detrimental to the trap's integrity.

During the past six years, Clearwater River trap efficiency for steelhead trout has been tested 20 times. Only 14 of these tests yielded valid results. The other six had recovery numbers less than five and could not be used in the analysis. An analysis of covariance shows a significant difference in trap efficiency among years ($F = 30.439$, $N = 14$, $P<0.001$). Therefore, data from all years were not pooled to derive any statistical inference. Hatchery steelhead trap efficiency ranged from 0.12% to 3.03% during the **six** years efficiency was tested and is generally below 0.5%.

Travel Time and Migration Rates

Release Sites to Snake River Trap

Chinook salmon-There were nine groups of freeze-branded chinook salmon released in the Salmon River drainage: three each at Sawtooth Hatchery, South Fork Salmon River and Rapid River Hatchery. Four groups were released in the Imnaha River, Oregon and four groups were released in Lookingglass Creek, Oregon.

Because of the extremely low brand recovery at the Snake River trap (146 branded chinook salmon were captured out of the approximately 381,863 branded fish released in 1991), migration rate statistics were calculated for only three release sites; South Fork Salmon River, Imnaha River, and Grande Ronde River. The migration rate for the South Fork Salmon River brand group was the slowest recorded to date (6.9 km/d). The low migration rate is explained by the late runoff from the upper Salmon River drainage which provided the second lowest mean discharge for the migration period in the Salmon River and the lowest mean discharge in the Snake River (Table 5). The Imnaha River brand release had the slowest migration rate for the two years of data (4.0 km/d). The 1991 Lookingglass Creek brand release had the slowest migration rate of six years of data (26.8 km/d). The mean discharge for the migration period for both the Imnaha and Lookingglass brand groups was the lowest since this project was initiated (Table 5). This low discharge was due to the drought situation and to the late spring runoff.

Steelhead trout-In 1991, there were no freeze-branded steelhead trout groups released above the Snake River trap from Idaho hatcheries. Fourteen groups of freeze-branded hatchery steelhead trout were released upstream from the Snake River trap by Oregon hatcheries: two groups of two replicates each from Little Sheep Creek, two groups of two replicates each from Spring Creek, two groups of two replicates each from Deer Creek, and one group of two replicates from Wildcat Creek. Recapture numbers were high enough for the seven combined replicate groups released in Oregon to provide travel time information to the Snake River trap (Table 6).

The two groups released from Spring Creek differed in size at release. Migration rates for the two paired release groups were 17.9 km/d for the four-to-the-pound and 13.1 km/d for the five-to-the-pound group. Migration rate for the combined four groups was 38% slower than for the brand groups from 1990 and the mean discharge for the migration period was down 28%. The migration rate for the Little Sheep Creek groups that were acclimated was 6.6 km/d and the migration rate for the groups that were a direct stream release was 8.0 km/d. The average migration rate for these groups was about half of the lowest year-to-date and mean discharge for the migration period was less than half (Table 6). The Wildcat Creek release traveled about three times slower in 1991 than in previous years (13.2 km/d) although discharge during the migration period was only about 20% less. Added to the standard freeze brand releases were two groups of steelhead trout released in Deer Creek. One group was acclimated and traveled at 4.6 km/d and the other group was a direct stream release and it traveled at 6.5 km/d (Table 6). Average discharge during the migration period was similar for both groups.

Release Sites to the Clearwater Trap

Chinook salmon-In 1991, there was one group of two replicates of freeze-branded chinook salmon released from DNFH on April 3 (Table 7). Travel time for the age 1 chinook salmon was 1 d. This compares to a travel time of 1 d in 1985, 1986, 1988 and 1989, and 4 d in 1987. Average discharge during the migration period in 1987 was 7,200 cfs, and was 25% to 76% less than in previous years. The extreme low discharge in 1987 is most likely responsible for the 75% reduction in travel time that year.

Table 5. Migration data for freeze-branded chinook salmon smolts from release sites to the Snake River trap, 1984 - 1991.

Release site	Year	Median release date	Median passage date	Number captured	Travel time (days)	Migration rate (km/day)	Mean 0 (kcfs) Salmon R.	Mean 0 (kcfs) Snake R.
Rapid River	1991	[a]--	--	--	--	--	--	--
	1990	[a]--	--	--	--	--	--	--
	1989	3/30	4/18	181	19	12.0	9.0	52.6
	1988	[a] - -			- -			
	1987	[a] - -		- -	- -	- -		
	1986	3/27	4/10	237	14	16.3	15.4	82.9
	1985	4/2	4/12	320	10	22.8	10.6	67.6
	1984	4/1	4/18	197	17	13.4	10.1	79.3
Hells Canyon	1991	[b]--	--	--	--	--	--	--
	1990	[b]--	--	--	--	--	--	--
	1989	[b]--	--	--	--	--	--	--
	1988	[6]--	--	--	--	--	--	--
	1987	[b]--	--	--	- -			--
	1986	3/26	4/3	269	8	21.6		83.8
	1985	3/19	4/3	544	14	12.4		43.0
	1984	3/20	3/29	704	9	19.2		81.4
S.F. Salmon River	1991	3/20	5/19	80	60	6.9	8.2	24.6
	1990	[a] - -	- -	- -	- -			
	1989	3/21	5/11	21	51	8.1	6.5	57.1
	1988	[a]				- -	--	--
	1987	[a] - -	- -	- -	- -	--	--	--
	1986	3/28	4/23	229	26	15.8	16.5	78.6
	1985	4/2	4/17	76	15	27.1	14.0	71.0
	1984	4/10	4/24	238	14	29.0	14.5	91.7
Sawtooth Hatchery	1991	[a]--	--	--	--	--	--	--
	1990	[a]--	--	--	--	- -	--	--
	1989	3/15	4/20	14	36	19.4	6.1	51.0
	1988	[a] - -	- -	- -	-	--	--	--
	1987	[a]--	--	--	--	- -	--	--
	1986	3/17	4/14	49	28	24.9	13.6	81.4
	1985	3/27	4/14	165	18	38.7	9.6	60.1
	1984	3/28	4/21	136	24	29.0	11.8	84.0

Table 5. Continued.

Release site	Year	Median release date	Median passage date	Number captured	Travel time (days)	Migration rate (km/day)	Mean Q (kcfs) Salmon R.	Snake R.
Lookingglass Cr.	1991	4/01	4/08	26	7	26.8	--	19.0
	1990	[a]--	--	--	--	--		
	1989	4/03	4/06	212	3	62.5	--	46.1
	1989	4/03	4/05	173	2	93.7	--	45.9
	1989	5/15	5/18	131	3	62.5	--	50.2
	1988	5/13	5/16	52	3	62.5	--	40.6
	1987	[a]--	--	--	--			
	1986	4/2	4/5	114	3	62.5	--	82.1
	1985	[b]--	--	--	--			
	1984	[b]--	--	--	--	--	--	--
Imnaha River	1991	3/22	4/12	31	21	4.0	--	18.0
	1990	'--	--	--	--			
	1989	4/05	4/10	247	5	16.8	--	51.6

[a] Insufficient recaptures numbers at the Snake River trap.
[b] No freeze brand releases made in that year.

Table 6. Migration data for freeze-branded steelhead trout smolts from release sites to the Snake River trap, 1985-1991.

Release site[a]	Year	Median release date	Median passage date	Number captured	Travel time (d)	Migration rate (km/d)	Mean discharge (kcfs)
Deer Creek	1991	4/26	5/10	79	14	4.6	27.1
		4/26	5/6	88	10	6.5	24.7
Spring Creek	1991	4/22	5/6	35	14	17.9	24.8
		4/22	5/10	38	19	13.1	26.4
	1990	4/17	4/30	115	13	18.6	35.6
		4/19	4/26	116	7	34.6	36.1
		4/17	4/28	125	11	22.0	35.0
	1989	4/24	5/1	84	7	34.6	62.0
		4/22	5/5	70	13	18.6	62.4
		4/22	5/2	83	10	24.2	63.8
	1988	4/17	4/25	28	8	30.3	34.5
		4/17	4/23	28	6	40.4	35.7
		4/17	4/25	30	8	30.3	34.5
		4/17	4/23	14	6	40.4	35.7
		4/18	4/25	38	7	34.6	35.0
		4/18	4/24	21	6	40.4	35.7
	1987	4/26	--[b]	--	--	--	--
	1986	5/1	5/27	14	26	9.3	72.9
		4/30	--[b]	1	--	--	--
		4/3	--[b]	2	--	--	--
	1985	5/9	5/19	36	10	24.2	46.4
		5/9	5/20	31	11	22.0	47.0

Table 6. Continued.

Release site[a]	Year	Median release date	Median passage date	Number captured	Travel time (days)	Migration rate (km/day)	Mean discharge (kcfs)
Little Sheep Creek	1991	4/23	5/11	59	18	8.0	27.2
		4/23	5/15	70	22	6.6	29.9
	1990	4/17	4/26	33	9	16.1	35.2
	1989	4/23	4/25	93	2	72.3	70.7
	1987	5/2	--[b]	--	--	--	--
	1986	4/28	5/8	16	10	14.5	72.1
		4/27	__[b]	2	--	--	--
Wildcat Creek	1991	4/30	5/10	121	10	13.2	28.2
	1990	4/25	4/28	84	3	44.2	34.7
	1989	4/26	4/30	134	4	33.2	60.7
	1988	4/23	4/26	152	3	44.2	32.7

[a]Only freeze brand groups from Oregon and Washington were used in 1989 and 1991 because Idaho did not **release** any freeze-branded steelhead trout above the Snake River trap during those years.

[b]Insufficient recaptures at the Snake River trap to derive fish movement data.

Table 7. Migration data for freeze-branded chinook salmon and steelhead trout smolts from release sites to the Clearwater River trap, 1987 - 1991.

Release Site	Year	Sp.	Median release date	Median passage date	Number captured	Travel time (d)	Migration rate (km/d)	Mean discharge (kcfs)
Dworshak NFH	1991	St	4/30	5/02	98	2	27.6	37.4
		Ch	4/03	4/04	465	1	55.1	11.9
Dworshak NFH	1990	St	5/3	5/4	1,060	1	55.0	22.3
		Ch	4/5	4/6	625	1	55.0	21.1
Dworshak NFH	1989	St	5/1	5/2	123	1	55.0	31.2
		Ch	3/29	3/3	139	1	55.0	23.5
		Ch	3/30	3/31	167	1	55.0	23.3
		Ch-0	3/30	4/3	48	4	13.8	22.2
		Ch	9/28/88	3/30	2	183	--	--
Red River	1989	Ch	10/17/88	4/17	19	182	--	--
Dworshak NFH	1988	St	5/3	5/4	283	1	55.0	16.9
		St	5/4	5/5	202	1	55.0	16.9
		Ch-0	3/30	4/1	239	2	27.5	9.8
		Ch	3/30	3/31	1,711	1	55.0	9.6
		Ch	3/30	3/31	1,359	1	55.0	9.6
		Ch	3/30	3/31	434	1	55.0	9.6
		Ch	9/28/87	3/27	16	182	--	--
Red River	1988	Ch	9/30/87	4/14	18	198	--	--
Crooked River	1987	St	4/14		2		--	--
Dworshak NFH	1987	St	4/21	4/22	58	--	--	--
		St	5/5	--	--	--	--	--
		Ch	4/1	4/4	1,416	3	18.3	7.2
Clear Creek	1987	St	4/17	4/20	59	3	38.3	14.1

Steelhead trout-There were eight groups of freeze-branded steelhead trout released from DNFH in 1991 totaling 57,561 fish. The median release date was April 30 and median passage date at the Clearwater trap was May 2 (Table 7). Percent brand recovery at the trap was very low, only 0.17%, because of poor trap location caused by very high discharge during this period and poor brand quality. The actual trap recovery of branded steelhead trout was 98 fish, which is a large sample for computing median date of passage. But the low recovery proportion may give an unrepresentative sample from the population. Therefore a 2-day travel time may be biased high since in all other years a 1-day estimate was observed. It appears safe to say that DNFH steelhead trout travel time was less than or equal to 2 days.

Head of Lower Granite Reservoir to Lower Granite Dam

Chinook salmon PIT tag groups-In 1991, sufficient numbers of chinook salmon were PIT-tagged daily at the Snake River trap to provide 25 daily release groups (2,131 total PIT-tagged chinook salmon) for estimating travel time and migration rates through Lower Granite Reservoir. The number of PIT-tagged chinook salmon at the Snake River trap was similar to 1990 but was down considerably from normal flow years due to poor trap catch associated with low river flows. Median travel time ranged from 16.4 d early in the migration season to 2.4 d in mid-May (Table 8). Travel time increased again, as discharge dropped after the peak discharge in mid-May. Travel time early in the migration season was similar to the previous year for that same period.

Upon examination of the linear regression analysis of migration rate and discharge a correlation was found. The linear regression of the log of migration rate and log discharge provided the best fit for PIT-tagged chinook salmon groups released from the Snake River trap ($r^2 = 0.851$, $N = 26$, $P = 0.000$):

In (migration rate) _ -2.739 + 1.152 In (average discharge).

This analysis indicates that PIT-tagged chinook salmon migration rate increased in Lower Granite Reservoir as discharge increased.

The linear regression analysis on the data stratified by 5-kcfs intervals provided the following best linear regression equation ($r^2 = 0.821$, $N = 14$, $P<0.001$):

In (migration rate) = -3.015 + 1.215 In (mean discharge).

The resulting r^2 shows there is a strong relation between migration rate and discharge. As discharge increases migration rate increases.

In 1991, chinook salmon smolts were PIT-tagged at the Clearwater River trap to provide travel time information through Lower Granite Reservoir for Clearwater River chinook salmon. Twenty-nine daily groups (totaling 3,976 chinook salmon) were released from the Clearwater River trap from April 3 through April 26, and from May 8 through May 12 (Table 9). The linear regression analysis of the

Table 8. PIT-tagged chinook salmon travel time, with 95% confidence intervals, from the Snake River trap to Lower Granite Dam, 1991.

Release date	Median travel time (day)	Confidence Interval[a] Lower	Upper	Number captured	Percent captured (%)	Average discharge (kcfs)
4/6,7,8	16.40	14.10	18.30	43	35.8	32.37
4/8[b]	16.45	14.30	19.00	36	36.0	31.84
4/9	16.20	14.50	17.60	42	42.0	31.89
4/10	14.20	13.10	14.60	63	41.7	31.23
4/11,12	12.05	10.20	13.30	32	33.7	30.74
4/12[b],13,16	14.10	12.30	16.00	58	42.3	34.12
4/15[b,c]	16.00	13.20	18.40	69	46.6	41.18
4/17[6]	10.60	9.50	13.00	66	36.7	38.21
4/18[b]	11.50	9.70	11.80	47	35.6	42.38
4/19[6,c]	15.40	10.50	17.50	55	35.9	48.08
4/22[b]	8.00	7.80	11.20	65	43.0	48.68
4/23[b]	8.25	7.30	11.20	62	40.8	52.14
4/25	6.45	4.60	7.80	36	36.4	57.48
4/25[b]	8.45	7.40	11.50	54	35.5	58.30
4/26	7.50	6.70	8.50	63	41.7	60.16
4/26[6]	7.30	3.70	14.30	21	39.6	60.07
4/27	7.80	7.50	9.50	81	53.3	60.49
4/28,29,30, and 5/1	8.20	6.50	9.40	53	42.4	56.78
4/29[b],30[b]	8.50	7.50	9.10	71	35.3	56.58
5/7,9	3.70	3.40	4.70	30	57.7	68.37
5/10	3.60	3.00	4.80	63	40.4	81.14
5/11,12,13	5.00	4.60	5.30	89	51.1	83.38
5/18,19	2.40	2.20	2.60	72	36.5	120.48
5/20	3.20	2.80	4.20	50	35.2	108.92
5/23,24,25	4.90	4.30	6.30	61	16.3	93.56
5/26	6.00	5.10	7.80	67	48.6	88.74
5/27,28,29	6.90	5.20	9.80	29	33.7	87.15
6/6`	10.65	5.70	23.10	8	44.4	89.53
6/11,12,13, 14,15,16`	6.90	4.90	10.10	28	37.8	77.98
6/20`	12.80	0.00	0.00	1	100.0	65.88
6/25`	4.30	0.00	0.00	1	50.0	65.34
6/28°	4.30	0.00	0.00	1	100.0	64.56
7/1`	5.20	0.00	0.00	1	25.0	63.31
7/3`	21.00	0.00	0.00	1	50.0	45.11

[a]Confidence intervals calculated with nonparametric statistics.
[b]Purse seine tagging groups.
[c]Not used in statistical analysis because analysis showed too few recaptures.

Table 9. PIT-tagged chinook salmon travel time, with 95% confidence intervals, from the Clearwater River trap to Lower Granite Dam, 1991.

Release date	Median travel time (day)	Confidence Interval[a] Lower	Upper	Number captured	Percent captured (%)	Average discharge (kcfs)
4/03	17.00	14.00	21.60	39	43.8	32.43
4/04	27.60	23.50	31.00	43	28.7	38.96
4/05	25.05	23.30	28.20	52	34.4	37.60
4/06	23.05	21.50	25.30	54	36.0	36.92
4/07	27.55	21.30	31.50	58	38.7	41.88
4/08	20.90	18.40	28.10	64	42.7	36.87
4/09	19.85	18.10	23.00	50	33.1	36.85
4/10	18.40	16.40	22.30	57	38.0	35.68
4/11	21.40	18.30	24.30	62	32.8	40.21
4/12	22.80	20.50	25.10	47	24.6	43.19
4/13	18.50	15.00	22.50	46	31.9	41.03
4/14	20.15	15.10	24.70	30	30.6	43.58
4/15	15.90	13.50	23.50	30	29.7	41.18
4/16	17.60	14.10	21.50	58	38.7	45.04
4/17	20.60	18.00	22.10	51	34.0	47.11
4/18	12.20	11.20	14.10	50	32.1	42.38
4/19	13.65	10.80	16.00	60	40.0	47.17
4/20	13.10	10.30	15.50	47	31.3	48.52
4/21	14.80	11.90	17.00	51	34.0	51.33
4/22	13.45	11.90	16.90	56	37.8	53.15
4/23	11.00	10.10	15.30	47	31.3	54.50
4/24	11.70	9.40	13.70	57	37.7	56.09
4/25	13.10	11.50	14.40	59	39.3	56.62
4/26	13.25	12.20	15.50	64	42.4	57.71
5/01[b]	9.10	6.70	15.10	9	47.4	58.94
5/07[b]	5.20	3.50	13.20	8	28.6	69.94
5/08	5.30	4.60	9.80	22	53.7	75.03
5/09	6.90	5.60	10.20	44	47.3	82.20
5/10	8.30	6.90	9.40	73	47.4	83.07
5/11	8.00	7.30	8.70	69	56.6	85.36
5/12	7.65	7.00	8.50	26	56.5	90.86

[a]Confidence intervals calculated with nonparametric statistics.
[b]Not used in statistical analysis because analysis showed too few recaptures.

Clearwater River chinook salmon PIT tag data showed a strong correlation between migration rate and discharge. (r^2 = 0.759, N = 29, P<0.001). The regression equation after stratifying by 5-kcfs groups was again significant and was fairly strong (r^2 = 0.821, N = 10, P<0.001):

$$\text{In (migration rate)} = -3.247 + 1.201 \ln \text{(mean discharge)}.$$

Similar to previous years, 1991 Clearwater River chinook salmon migrated slower than Snake River chinook salmon. There are 18 release groups with comparable release dates for the two traps. The median migration rate for these days was 5.7 km/d for chinook salmon released from the Snake River trap and 4.3 km/d for chinook salmon released from the Clearwater River trap. The reasons that the Clearwater River chinook salmon migrate slower through Lower Granite Reservoir than Snake River fish during the same time period are unclear at this time.

Preliminary ATPase data, collected by the U.S. Fish and Wildlife Service, from chinook salmon smolts collected in the Clearwater and Snake River traps in 1990 (Rondorf et al. in press) were examined. There were only four data points from the Snake and Clearwater River traps that were comparable. The data indicate that smolts from the Snake River trap had significantly higher weekly ATPase levels (}moles P•mg $Prot^{-1}$ •h^{-1}) than smolts from the Clearwater River trap. This demonstrates that Snake River chinook salmon were at a higher level of smoltification than Clearwater River fish. Mean seasonal ATPase levels for the four comparable data points were 13.3 µmoles for the Clearwater River smolts and 22.2 }moles for the Snake River smolts. These ATPase differences probably explain some, but not all, of the difference in migration rate between Snake River and Clearwater River trap-caught chinook salmon.

The chinook salmon migration rate/discharge relation for Snake River trap PIT tag groups was examined to determine if there was a difference in this relation between years (1987-1991). The analysis of covariance was used with the data averaged by 5-kcfs groups. The analysis showed a significant difference in the migration rate/discharge relation between years (slope of the lines) at the 0.05 level of significance (F = 12.212, N = 48, P<0.001). A graph of the data showed that 1989 data had a slightly steeper slope (Figure 8). After removing the 1989 data the analysis was rerun. A significant difference in the slopes could not be detected at the 0.05 level of significance (F = 1.887, N = 38, P = 0.153). The analysis of covariance was continued to test for a difference in the height of the lines for the four years of data. Again, no difference could be detected (F = 2.398, N = 38, P = 0.086), indicating a common migration rate/discharge relation for chinook salmon for the four years.

Upon graphing the 1987 through 1991 migration rate/discharge equations for chinook, it becomes very apparent that in the discharge range between 60 and 100 kcfs, all years showed the same basic relation. The amount of increase between 60 and 100 kcfs is consistent for 1987, 1988, 1990, and 1991 (two-fold) but slightly higher for 1989 (three-fold). The same trend exists in all five years; increased flow in Lower Granite Reservoir increases migration rate through the reservoir.

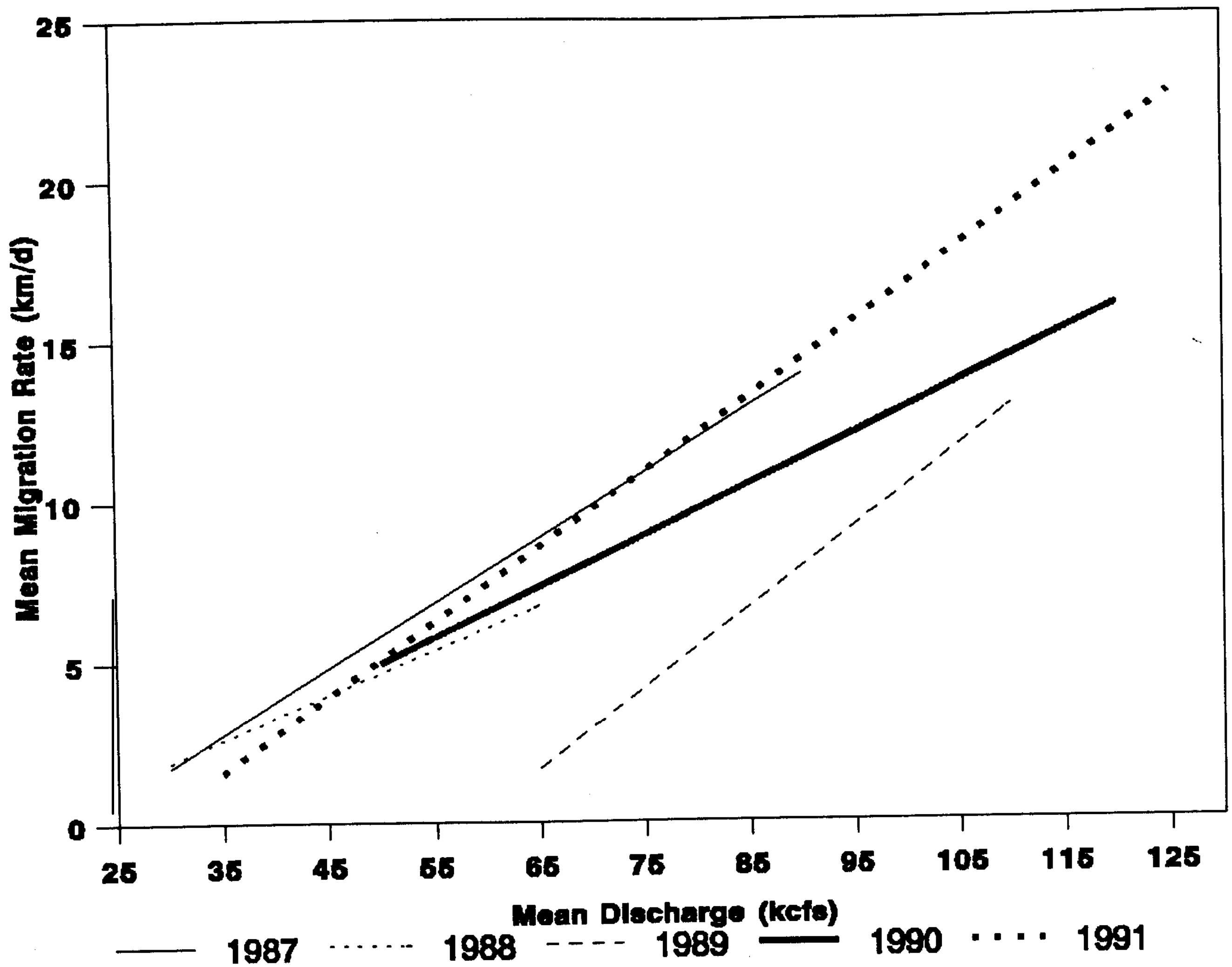

Figure 8. Chinook salmon migration rate/discharge relations for Snake River trap PIT tag groups, 1987-1991.

Percent recovery (interrogation) at Lower Granite Dam of daily groups of chinook salmon PIT-tagged at the Snake River trap ranged between 16.3% and 53.3%. Seasonal cumulative recovery (# recaptured/# marked) of PIT-tagged chinook salmon to Lower Granite Dam was 43.6%. Cumulative recovery progressing downstream to Little Goose Dam was 62.8% and to McNary Dam was 68.2%.

Percent recovery of Clearwater River trap daily release PIT-tagged chinook salmon groups at Lower Granite Dam ranged between 24.6% and 73.2%. Seasonal cumulative recovery of PIT-tagged chinook salmon to Lower Granite Dam was 37.6%. Cumulative recovery progressing downstream to Little Goose Dam was 54.5% and to McNary Dam was 60.5%.

Hatchery steelhead trout PIT tag groups-Sufficient numbers of hatchery steelhead trout were PIT-tagged daily at the Snake River trap to provide 50 daily release groups (2,577 individual fish) to be used in median migration rate calculations through Lower Granite Reservoir. Median travel time ranged from 11.5 to 1.8 d (4.5 km/d to 28.7 km/d migration rate) and averaged 4.5 d, which was the same as 1990 (Table 10).

The linear regression analysis showed a significant relation between migration rate in Lower Granite Reservoir and average Lower Granite discharge (inflow) for PIT-tagged hatchery steelhead trout groups (r^2 = 0.849, N = 50, $P<0.001$). The best linear regression equation was:

$$\text{in (migration rate)} = -4.359 + 1.577 \ln \text{(mean discharge)}.$$

The linear regression equation for the daily release groups stratified into 5-kcfs discharge intervals was (r^2 = 0.938, N = 13, $P<0.001$):

$$\text{In (migration rate)} = -4.523 + 1.610 \ln \text{(mean discharge)}.$$

The equation shows that as discharge increases, migration rate increases for PIT-tagged hatchery steelhead trout marked at the Snake River trap.

Twenty-two groups of hatchery steelhead trout (1,215 individual fish) were PIT-tagged at the Clearwater River trap in 1991 for use in median migration rate calculations through Lower Granite Reservoir (Table 11). Median travel time ranged from 9.9 to 4.9 d (6.2 km/d to 12.7 km/d) and averaged 7.5 d (8.2 km/d). Average inflow discharge to Lower Granite Reservoir during the migration season was 60.2 kcfs and ranged from 35.8 to 85.0 kcfs.

The linear regression analysis detected a significant relation between migration rate in Lower Granite Reservoir and average Lower Granite inflow discharge for Clearwater River PIT-tagged hatchery steelhead trout (r^2 = 0.412, N = 22, P = 0.001). The data, stratified by 5-kcfs discharge groups, likewise, detected a significant relation between discharge and migration rate after stratification (r^2 = 0.634, N = 11, P = 0.003):

$$\text{In (migration rate)} = -0.054 + 0.537 \text{ In (mean discharge)}.$$

Hatchery steelhead trout migration rate/discharge relation among years for fish PIT-tagged at the Snake River trap was examined to see if the relation was

Table 10. PIT-tagged hatchery steelhead travel time, with 95% confidence intervals, from the Snake River trap to Lower Granite Dam, 1991.

Release date	Median travel time (day)	Confidence Interval[a] Upper	Lower	Number captured	Percent captured (%)	Average discharge (kcfs)
4/16	11.50	8.60	16.00	25	73.5	37.55
4/25	7.90	5.70	9.60	57	89.1	58.29
4/26	7.70	4.90	9.40	45	72.6	60.16
4/27	6.55	5.60	9.60	48	76.2	60.67
4/28	6.80	6.30	9.00	48	78.7	59.91
4/29	5.90	4.70	9.80	52	85.2	59.95
4/30	6.10	4.80	10.50	57	81.4	58.37
5/1	7.80	5.60	11.00	47	55.3	56.40
5/2	6.10	4.70	8.80	33	45.2	55.27
5/3	7.30	6.00	8.80	46	76.7	58.43
5/4	7.10	5.60	8.50	44	73.3	61.05
5/5	7.55	5.50	9.20	46	85.2	65.59
5/6	6.40	5.10	8.60	45	75.0	65.93
5/7	5.05	4.10	5.70	44	73.3	69.94
5/8	4.70	3.80	5.00	49	79.0	75.03
5/9	3.70	3.50	4.70	48	80.0	78.78
5/10	3.90	3.60	4.70	52	82.5	81.14
5/11	3.90	3.60	4.70	46	75.4	82.15
5/12	3.90	3.20	4.50	51	85.0	85.18
5/13	3.80	3.40	5.60	50	83.3	86.17
5/14	3.65	2.80	5.40	48	80.0	85.00
5/15	4.45	3.70	5.10	50	82.0	88.58
5/16	3.50	3.00	3.70	48	80.0	96.53
5/17	3.00	2.70	3.20	56	78.9	100.57
5/18	2.00	1.90	2.10	43	86.0	108.84
5/19	1.80	1.60	1.90	55	83.3	120.48
5/20	2.10	1.90	3.50	51	85.0	113.47
5/23	2.00	1.70	3.00	50	83.3	105.32
5/24	2.55	2.10	3.20	52	86.7	104.21
5/25	3.00	2.80	3.80	41	65.1	98.85
5/26	3.20	3.00	4.50	45	75.0	91.68
5/27	2.90	2.70	3.50	54	80.6	86.74
5/28	3.35	2.80	3.80	50	83.3	85.70
5/29	3.10	2.60	5.50	21	35.0	85.80
5/30	4.15	3.20	4.50	38	63.3	85.66
5/31	3.75	3.20	4.50	52	86.7	88.23
6/1	3.45	2.70	4.30	24	85.7	89.12
6/2	3.20	2.80	4.90	21	77.8	96.08
6/3	4.65	1.90	7.10	10	55.6	95.52
6/4	3.15	2.80	3.70	36	81.8	95.92
6/5	3.15	2.80	4.00	30	75.0	92.41
6/6	3.20	2.80	4.20	31	83.8	90.84
6/11	3.20	2.20	4.20	19	76.0	101.81
6/12	3.10	2.90	3.40	47	77.0	98.49
6/13	3.10	2.50	4.00	31	81.6	90.98
6/14	3.95	3.50	4.20	28	93.3	77.00
6/15	3.80	1.80	4.30	9	75.0	71.31
6/16	4.35	2.90	9.30	6	60.0	68.24
6/17	4.20	2.70	5.80	8	61.5	67.74
6/21	3.65	2.90	4.00	16	53.3	65.85

[a]Confidence intervals calculated with nonparametric statistics.

Table 11. PIT-tagged hatchery steelhead trout travel time, with 95% confidence intervals, from the Clearwater River trap to Lower Granite Dam, 1991.

Release date	Median travel time (day)	Confidence Interval[a] Lower	Upper	Number captured	Percent captured (%)	Average discharge (kcfs)
4/17	9.85	8.20	11.10	40	65.6	35.58
4/18	8.95	8.10	10.40	40	66.7	36.23
4/19	8.25	7.00	9.10	38	59.4	37.06
4/20	7.65	6.90	9.70	48	73.8	41.44
4/21	8.15	6.90	9.20	42	70.0	45.20
4/22	6.35	5.60	7.90	46	75.4	45.25
4/23	7.30	5.90	8.30	48	80.0	51.03
4/24	8.40	5.50	9.70	44	80.0	55.30
4/25	8.30	6.90	10.60	49	83.1	58.29
4/26	7.10	6.40	8.70	45	78.9	60.07
5/1	9.30	5.90	12.50	29	74.4	58.94
5/2	8.05	6.30	10.30	52	85.2	58.87
5/3	9.25	7.40	11.70	44	73.3	62.71
5/4	7.70	6.70	8.60	52	85.2	62.94
5/5	7.75	6.70	9.50	48	80.0	65.59
5/6	6.50	5.60	8.60	42	68.9	68.01
5/7	7.30	5.50	9.90	46	73.0	74.13
5/8	5.70	4.70	7.30	63	94.0	77.32
5/9	4.85	4.50	6.40	50	82.0	80.77
5/10	5.30	3.80	7.50	47	79.7	81.55
5/11	7.40	2.40	18.10	7	53.8	83.63
5/12	5.05	2.80	6.40	6	75.0	85.03

[a]Confidence intervals calculated with nonparametric statistics.

constant over years. Analysis of covariance on the log transformed data was used to determine if there was a significant difference between years (1987-1991) in migration rate averaged by 5-kcfs intervals. The analysis did not detect a difference among years (slopes of the lines) for the hatchery steelhead trout migration rate/discharge relation at the 0.05 level of significance ($F = 2.402$, $N = 59$, $P = 0.062$). The analysis was continued to determine if the intercepts (heights) of the lines were different. The analysis showed there was a significant difference in the intercepts of the lines. After examining a graph of the data, the 1987 data were significantly higher than the other years (Figure 9). When the 1987 data were removed and the analysis run again there was not a significant difference in the height of the remaining years data. The 1988 through 1991 data were pooled and the linear regression analysis conducted ($r^2 = 0.906$, $N = 49$, $P<0.001$):

In (migration rate) = -4.028 + 1.517 ln (mean discharge).

The equation shows that PIT-tagged hatchery steelhead trout from the Snake River trap move more than five times faster through Lower Granite Reservoir at 120 kcfs as they do at 40 kcfs. The analysis shows that the migration rate/discharge relation for these fish is not only consistent during the outmigration season but consistent year to year.

Percent recovery of Snake River trap daily hatchery steelhead trout PIT tag release groups at Lower Granite Dam ranged from 35.0% to 93.3%. Seasonal cumulative recovery of PIT-tagged hatchery steelhead trout to Lower Granite Dam was 78.9%, to Little Goose Dam 89.3%, and to McNary Dam 89.7%.

Percent recovery of Clearwater River trap daily hatchery steelhead trout PIT tag release groups at Lower Granite Dam ranged from 53.8% to 94.0%. Seasonal cumulative recovery of PIT-tagged hatchery steelhead trout to Lower Granite Dam was 76.2%, to Little Goose Dam 83.5%, and to McNary Dam 83.8%. This was 5.9% less than for fish PIT-tagged at the Snake River trap.

<u>Wild steelhead trout PIT tag </u>groups-Sufficient numbers of wild steelhead trout were PIT-tagged at the Snake River trap to provide 35 daily release groups (3,570 individual fish) for estimating travel time and migration rate in Lower Granite Reservoir (Table 12). Median travel time ranged from 10.1 d (5.1 km/d) to 1.5 d (34.4 km/d) and averaged 3.8 d (13.6 km/d). Linear regression analysis showed a strong significant relation between median migration rate in Lower Granite Reservoir and mean discharge for PIT-tagged wild steelhead trout groups ($r^2 = 0.867$, $N = 35$, $P<0.001$). The best linear regression equation was:

In (migration rate) = -2.004 + 1.091 In (mean discharge).

The analysis shows that as discharge increases migration rate in Lower Granite Reservoir increases.

Linear regression equation for PIT tag groups stratified into 5-kcfs intervals ($r^2 = 0.873$, $N = 15$, $P<0.001$) was:

in (migration rate) = -2.311 + 1.156 In (mean discharge).

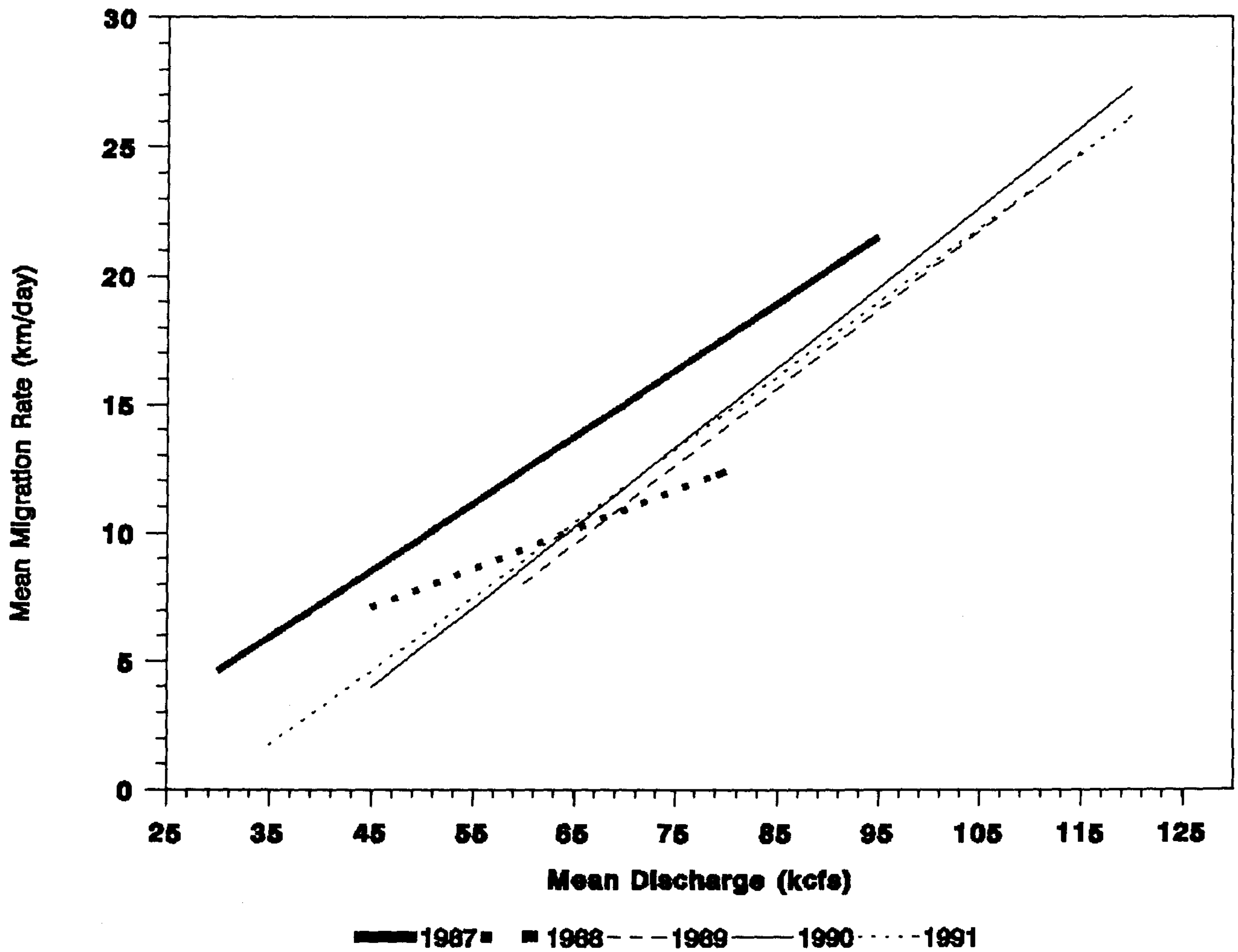

Figure 9. Hatchery Steelhead trout migration rate/discharge relations for Snake River trap PIT tag groups, 1987-1991.

Table 12. PIT tagged wild steelhead trout travel time, with 95% confidence intervals, from the Snake River trap to Lower Granite Dam, 1991.

Release date	Median travel time (day)	Confidence Interval[a] Upper	Lower	Number captured	Percent captured (%)	Average discharge (kcfs)
04/06,08,09/91	7.25	5.90	22.20	8	57.1	33.34
04/10/91	8.05	5.80	11.20	10	66.7	31.45
04/11,12,13,16/91	10.10	6.90	16.70	10	62.5	30.24
04/25/91	4.25	3.70	5.50	30	71.4	56.69
04/26/91	5.00	4.40	6.00	57	64.8	59.80
04/27/91	4.70	3.90	5.50	50	61.7	60.38
04/28/91	4.50	4.10	5.10	49	61.3	59.86
04/29/91	5.40	3.70	7.00	26	61.9	60.08
04/30/91	3.85	3.50	5.30	18	58.1	60.56
05/01/91	4.70	2.70	9.80	14	48.3	58.05
05/02,04,05/91	4.40	3.60	6.10	11	64.7	52.21
05/06/91	4.40	2.80	10.70	7	50.0	60.05
05/07/91	3.70	3.50	4.30	42	76.4	68.37
05/08/91	3.50	2.90	3.80	21	72.4	73.67
05/09/91	3.40	2.90	3.60	47	68.1	78.22
05/10/91	3.10	3.00	3.40	358	55.4	78.61
05/11/91	3.10	2.80	3.40	188	60.3	81.80
05/12/91	3.20	2.80	3.50	113	61.7	84.13
05/13/91	3.00	2.70	3.50	59	18.5	86.75
05/14/91	3.20	2.80	3.50	84	67.2	85.31
05/15/91	3.60	3.20	4.50	56	68.3	88.58
05/16/91	3.70	2.70	4.10	29	63.0	96.53
05/17/91	2.60	2.50	2.70	85	65.9	100.57
05/18/91	2.00	1.90	2.20	152	64.7	108.84
05/19/91	1.50	1.40	1.50	339	73.5	120.48
05/20/91	2.10	1.90	2.40	51	71.8	113.47
05/23/91	2.10	1.80	3.60	32	66.7	105.32
05/24/91	1.85	1.70	2.90	26	74.3	105.93
05/25/91	2.30	2.00	3.00	55	56.7	103.78
05/26/91	2.80	2.50	3.70	35	72.9	91.68
05/27/91	2.70	2.40	3.00	21	65.6	86.74
05/28/91	3.20	2.70	4.00	23	74.2	85.70
05/29/91	2.55	1.80	3.50	10	71.4	85.80
05/31-06/01,02,03/91	4.10	2.60	5.20	10	71.4	95.17
06/04,05,06191	2.75	2.60	9.20	6	60.0	92.41
06/11,12/91[b]	2.20	0.00	0.00	3	60.0	101.50
06/21,22/91[b]	4.40	0.00	0.00	2	40.0	64.78

[a]Confidence intervals calculated with nonparametric statistics.
[b]Not used in statistical analysis because analysis showed too few recaptures.

This indicates that 87% of the variation in migration rate is accounted for by changes in discharge. In other words, migration rate is very dependent on discharge; the higher the discharge, the faster wild steelhead trout migrate.

Twenty-two wild steelhead trout PIT-tagged groups (713 individual fish) were released from the Clearwater River trap in 1991 for use in median migration rate calculations through Lower Granite Reservoir (Table 13). Median travel time ranged from 9.8 d to 3.4 d (6.3 to 18.1 km/d respectively) and averaged 6.3 d (9.8 km/d). Average discharge for the PIT-tagged wild steelhead trout migration season was 51.1 kcfs.

The linear regression analysis showed a significant relation between migration rate in Lower Granite Reservoir and average inflow discharge to the Reservoir for wild steelhead trout groups released from the Clearwater River trap ($r^2 = 0.924$, $N = 22$, $P<0.001$). The best linear regression equation was:

$$\text{In (migration rate)} = -1.395 + 0.967 \text{ In (mean discharge)}.$$

The linear regression equation for PIT tag groups stratified into 5-kcfs intervals ($r^2 = 0.921$, $N = 10$, $P<0.001$) was:

$$\ln \text{(migration rate)} = -1.820 + 1.066 \ln \text{(mean discharge)}.$$

This indicates that 92% of the variation in wild steelhead trout migration rate for fish released from the Clearwater River trap is accounted for by changes in discharge. Discharge is a very important variable associated with the rate of movement of wild steelhead trout. As discharge increases so does migration rate.

Wild steelhead trout migration rate/discharge relation for fish released from the Snake River trap was examined to see if this relation was constant over years. The analysis of covariance was used to determine if there was a significant difference among years (1987-1991) in migration rates using groups averaged by 5-kcfs intervals. The analysis showed no significant difference among years for the slopes of the wild steelhead trout migration rate/discharge relations ($F = 1.149$, $N = 55$, $P = 0.346$) nor was there a significant difference in migration rate (intercept) between years ($F = 1.682$, $N = 55$, $P = 0.169$). The data were pooled and the linear regression analysis was run using the log transformed data ($r^2 = 0.821$, $N = 55$, $P<0.001$). The best linear regression equation was:

$$\ln \text{(migration rate)} = -2.069 + 1.115 \ln \text{(mean discharge)}.$$

The analysis indicates that 82% of the variation in migration rate for PIT-tagged wild steelhead trout released from the Snake River trap between 1987 and 1991 was accounted for by changes in discharge. The equation shows that a two-fold increase in discharge will increase migration rate 2.2 times.

Percent recovery at Lower Granite Dam of daily wild steelhead trout PIT tag groups released from the Snake River trap ranged from 18.5% to 76.4%. Seasonal cumulative recovery of PIT-tagged wild steelhead trout to Lower Granite Dam was 63.9%, to Little Goose Dam 81.5%, and to McNary Dam 83.3%.

Table 13. PIT-tagged wild steelhead trout travel time, with 95% confidence intervals, from the Clearwater River trap to Lower Granite Dam, 1991.

Release date	Median travel time (day)	Confidence Interval[a] Upper	Lower	Number captured	Percent captured (%)	Average discharge (kcfs)
4/8	9.80	7.70	13.20	13	59.1	32.38
4/9	9.55	6.50	12.20	10	58.8	31.62
4/10	9.25	6.80	13.20	8	57.1	31.25
4/11	9.40	5.70	12.80	8	40.0	30.61
4/12	9.50	7.40	12.50	10	50.0	30.24
4/13,14	8.30	5.80	13.50	7	58.3	30.05
4/15,16	9.25	5.40	19.70	8	57.1	31.51
4/17	7.20	0.00	0.00	5	41.7	30.76
4/19,21	6.20	5.10	7.70	9	50.0	39.56
4/22	5.70	5.00	8.30	17	56.7	45.25
4/23	5.60	4.90	6.10	37	56.9	49.84
4/24	4.70	4.40	5.40	56	57.7	52.95
4/25	5.10	4.40	6.10	69	56.6	56.99
4/26	5.30	4.40	5.70	29	58.0	59.80
5/1,2	4.60	0.00	0.00	5	50.0	58.05
5/4,5	5.85	4.30	8.70	6	60.0	61.35
5/6	4.90	3.70	6.70	7	58.3	63.88
5/7	4.00	3.50	4.40	21	72.4	68.37
5/8	3.40	2.60	4.30	17	47.2	72.83
5/9	3.65	3.20	3.90	32	65.3	78.78
5/10	3.50	2.60	3.80	26	66.7	81.14
5/12	3.40	0.00	0.00	5	100.0	84.13

[a]Confidence intervals calculated with nonparametric statistics.

The percent recovery at the three dams for PIT-tagged hatchery and wild steelhead trout was about the same, 89.7% for hatchery steelhead trout and 83.3% for wild steelhead trout marked at the Snake River trap. Interrogation rates for hatchery and wild steelhead trout marked at the Clearwater River trap were 83.8% and 74.1%, respectively. The cumulative recovery rates at the three dams for both chinook salmon and hatchery and wild steelhead trout were slightly higher in 1991 than in previous years.

Percent recovery of daily wild steelhead trout PIT tag groups released from the Clearwater River trap and interrogated at Lower Granite Dam ranged from 40.0% to 72.4%. Seasonal cumulative recovery of PIT-tagged wild steelhead trout released at the Clearwater River trap to Lower Granite Dam was 56.3%, to Little Goose Dam was 70.3%, and to McNary Dam was 74.1%.

Migration rates for hatchery and wild steelhead trout PIT-tagged at the Snake River trap were significantly different. The slopes of the migration rate/discharge regression lines for hatchery and wild steelhead trout, grouped by 5-kcfs intervals, were tested with the analysis of covariance and found to be significantly different ($F = 8.151$, $N = 29$, $P = 0.009$). In 1991, wild steelhead trout from the Snake River trap migrated 1.5 times faster than hatchery steelhead trout at low discharge (50,000 cfs) and at about the same rate at 120,000 cfs (Figure 10). In 1988 and 1989, there was no difference in the migration rate discharge relation but wild steelhead trout consistently migrated faster than hatchery smolts (2.5 km/d, 3 km/d faster, respectively). It is uncertain as to the reason for this difference. Possible explanations are that wild steelhead trout are stronger and/or more fully smolted and therefore migrate faster through Lower Granite Reservoir at low discharge. At high discharge the ability of the river to carry fish downstream makes up for the difference in the ability to migrate between hatchery and wild steelhead.

Mean ATPase activity level, an indicator of smoltification, was tested at the Snake River trap between April 20 and June 1, 1990 (Rondorf et al. in press). Preliminary information indicates weekly ATPase levels for hatchery steelhead trout were about 50% lower than wild steelhead trout at the beginning of this period and at about the same level at the end of this period. Hatchery steelhead trout weekly mean ATPase levels started out at 11.4 µmoles P•mg $Prot^{-1}$•h^{-1}, peaked at 25.0 µmoles the week of May 25 and ended at 21.8 µmoles. Wild steelhead trout weekly mean ATPase levels fluctuated little during the sample period, ranging from 18.0 to 23.7 µmoles P•mg $Prot^{-1}$•h^{-1}.

Head of Lower Granite Reservoir to Little Goose Dam

Chinook salmon PIT tag groups-The relation between migration rate and discharge was examined for PIT-tagged chinook salmon released from the Snake River trap and interrogated at Little Goose Dam. The linear regression analysis, on the log transformed data stratified by 5-kcfs intervals (Table 14), showed that 72% of the variation in PIT-tagged chinook salmon migration rate between the Snake River trap and Little Goose dam was accounted for by

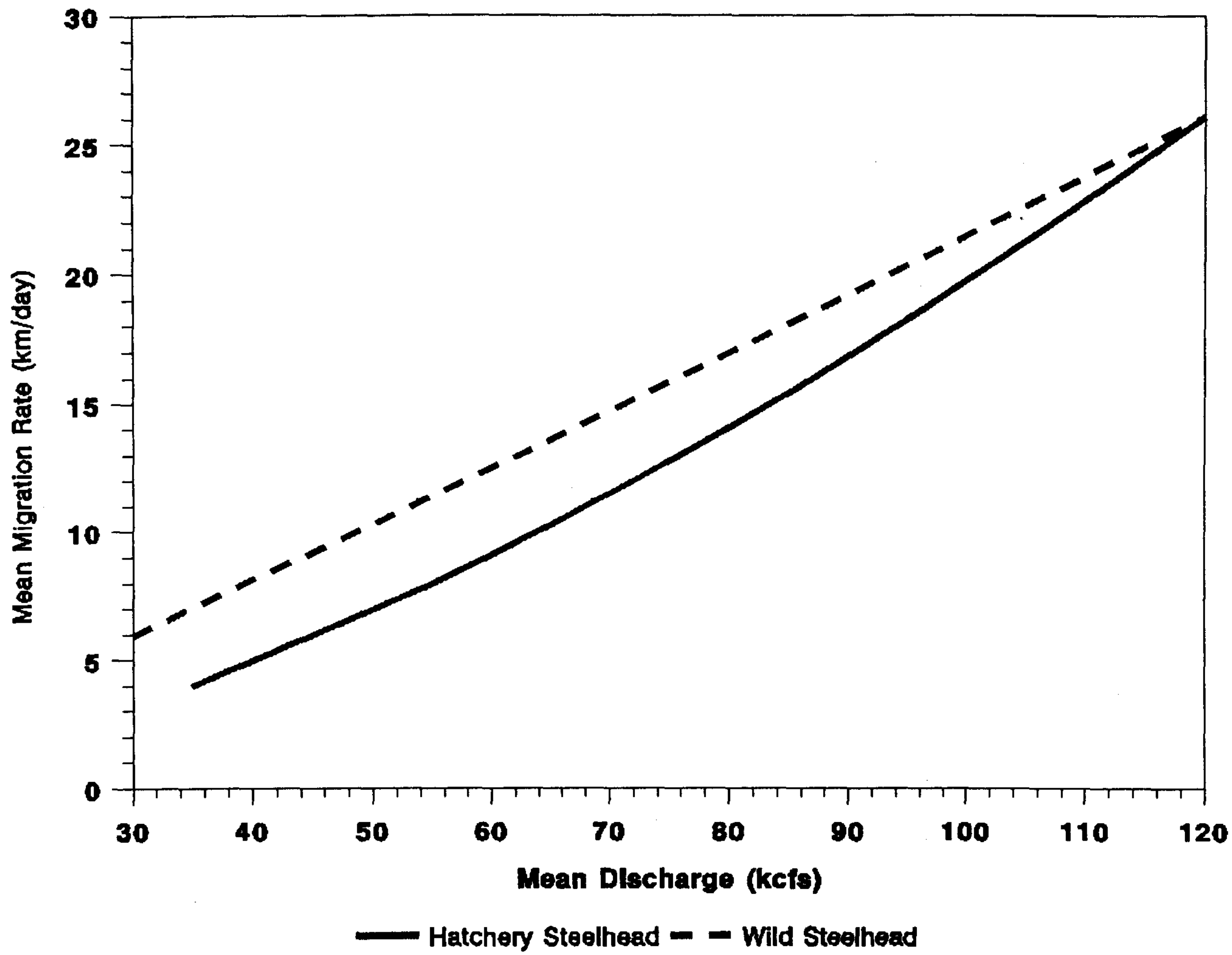

Figure 10. Hatchery and wild steelhead trout migration rate/discharge relation for Snake River trap PIT tag groups, 1991.

Table 14. Migration data, stratified by 5-kcfs intervals, for chinook salmon from Snake and Clearwater River traps to Little Goose Dam, 1991.

Discharge Interval		Snake River Trap Migration Rate (km/d)	Clearwater River Trap Migration Rate (km/d)
30	35	--	--
35	40	5.85	
40	45	--	4.24
45	50	--	5.00
50	55	--	5.73
55	60	9.67	5.37
60	65	8.40	6.05
65	70	--	6.10
70	75	--	--
75	80	--	5.50
80	85	--	--
85	90	12.70	8.10
90	95	11.20	9.67
95	100	11.40	10.10
100	105	12.90	--
105	110	24.40	--
110	115	26.30	--
115	120	--	--

discharge (r^2 = 0.717, N = 9, P = 0.004). The same analysis was conducted on the PIT tag chinook salmon data from the Clearwater River trap (Table 14). This analysis showed that 83% of the variation in the migration rate for chinook salmon from the Clearwater River trap to Little Goose Dam was accounted for by discharge (r^2 = 0.826, N = 10, P<0.001).

Hatchery steelhead trout PIT tag groups-The migration rate/discharge relation for PIT-tagged hatchery steelhead trout released from the Snake River trap and interrogated at Little Goose Dam was examined using the linear regression analysis. The data were stratified by 5-kcfs intervals and log transformed (Table 15). Seventy-one percent of the variation in PIT-tagged hatchery steelhead trout migration rate is accounted for by discharge (r^2 = 0.710, N = 10, P = 0.002). Not enough hatchery steelhead trout, PIT-tagged at the Clearwater River trap, were interrogated at Little Goose Dam in 1991 to conduct this analysis.

Wild steelhead trout PIT tag groups-The migration rate/discharge relation for wild steelhead trout PIT-tagged and released from the Snake River trap was examined using the linear regression analysis. The data were stratified by 5-kcfs intervals and log transformed (Table 16). The analysis showed that 93% of the variation in migration rate is accounted for by discharge (r^2 = 0.933, N = 10, P<0.001). Not enough wild steelhead trout, that were PIT-tagged at the Clearwater River trap, were interrogated at Little Goose Dam to perform this analysis. In those instances where enough data exist (Snake River trap data for chinook salmon, hatchery steelhead trout, and wild steelhead trout, and Clearwater River trap data for chinook salmon), the regression shows a significant relation.

Age 0 Chinook vs. Age 1 Chinook Migration Rate and Survival

Five parameters (minimum survival estimate, travel time, migration rate/discharge relation, average length, and growth rate) were examined to determine if age 0 and age 1 chinook salmon could be separated by external physical characteristics at the traps. Minimum survival estimate (age 0 chinook = 51.1%, age 1 chinook = 84.6%), migration rate/discharge relation, and average length at tagging showed a significant difference between those fish classified as age 0 chinook and age 1 chinook. A t-test was used to determine if a significant difference existed in the mean length of age 0 and age 1 chinook (t = 3.41). The analysis of covariance detected a difference in the slopes of the migration rate/discharge relation equations (F = 6.399, N = 12, P = 0.035). Growth rate (age 0 chinook = 1.12 mm/d, age 1 chinook = 1.08 mm/d) and migration rate are not reliable variables to separate these two groups of chinook. Migration rate may show a difference between age 0 and age 1 chinook (age 0 chinook = 4.0 km/d at an average discharge of 64.3 kcfs, age 1 chinook = 7.1 km/d at an average discharge of 74.9 kcfs), but because the average migration rates were calculated over different average discharges, they are not easily compared.

Table 15. Migration data, stratified by 5-kcfs intervals, for hatchery steelhead trout from Snake and Clearwater River traps to Little Goose Dam, 1991.

Discharge Interval		Snake River Trap Migration Rate (km/d)	Clearwater River Trap Migration Rate (km/d)
30	35	--	--
35	40	--	
40	45	--	8.10
45	50	--	-
50	55	--	12.50
55	60	11.90	9.90
60	65	--	--
65	70	8.60	--
70	75	8.70	8.50
75	80	10.90	9.80
80	85	16.80	9.70
85	90	19.25	13.50
90	95	21.75	9.80
95	100	20.50	--
100	105	18.10	--
105	110		--
110	115	31.80	--
115	120	--	--

Table 16. Migration data, stratified by 5-kcfs intervals, for wild steelhead trout from Snake and Clearwater River traps to Little Goose Dam, 1991.

Discharge Interval		Snake River Trap Migration Rate (km/d)	Clearwater River Trap Rate (km/d)
30	35	8.10	9.10
35	40	--	8.47
40	45	--	10.00
45	50	--	13.20
50	55	--	9.60
55	60	16.10	14.00
60	65	17.50	14.25
65	70		
70	75		12.70
75	80		16.90
80	85	22.10	18.20
85	90	23.05	--
90	95	19.55	--
95	100	29.50	--
10	10	31.80	--
10	11	27.50	--
11	115	31.90	--
115	120	--	--

Not enough data are available to perform a statistical analysis between migration rate and discharge for age 0 and age 1 chinook salmon PIT tagged after June 12.

Minimum Survival of PIT-tagged Fish

Minimum survival to Lower Granite Dam (the number of fish that were interrogated at Lower Granite, Little Goose, or McNary dams) for fish PIT- tagged at the Snake River and Clearwater River traps in 1991 was slightly higher than minimum survival estimates from previous years. Chinook salmon and both hatchery and wild steelhead trout PIT-tagged at the Snake River trap survived at a rate 5.9 to 7.9 percentage points higher than fish tagged at the Clearwater River trap (Table 17). This follows a similar trend observed in 1989 and 1990. The difference in minimum survival, in part, can be accounted for by the presence of DNFH releases. Due to the close proximity of the Clearwater River trap to the hatchery, the rigors of migration have not as yet caused mortality of the weaker fish. Natural mortality of hatchery fish is believed to be greater at the beginning of their river existence as they acclimate to the hazards present in the natural system. The majority of the mortality of hatchery fish in the Snake River takes place prior to the fish passing the trap site. This does not explain the difference in minimum survival for wild steelhead.

Minimum survival to Lower Granite Dam in 1991 for chinook salmon (68.2%), hatchery steelhead trout (89.7%), and wild steelhead trout (83.3%) from the Snake River trap was slightly higher than in 1989 or 1990. The minimum survival estimate to Lower Granite Dam for chinook salmon PIT-tagged at the Clearwater River trap (60.5%), hatchery steelhead trout (83.8%), and wild steelhead trout (74.1%) was slightly higher than observed in 1989 and 1990.

SUMMARY

The number of hatchery-reared chinook salmon and steelhead trout released above Lower Granite Dam was up considerably in 1991. Chinook salmon releases were down 35% and hatchery steelhead trout releases were down 13% from 1990. There was a major decrease in chinook salmon production in the Salmon River drainage and minor reductions in the Clearwater and Grande Ronde rivers in 1991. The majority of the decrease in hatchery steelhead trout production occurred in the Salmon River drainage. Hatchery production of chinook salmon and steelhead trout released above Lower Granite Dam was 19,539,185 (9,645,205 chinook salmon and 9,893,980 steelhead trout) in 1991. Of these, 381,863 chinook salmon and 355,796 steelhead trout (4.0% and 3.6% of the total releases, respectively) were freeze-branded and released as 19 unique chinook salmon groups and 21 unique steelhead trout groups.

The Snake River trap was operated on the east side of the river from March 11 through August 12. The Snake River trap captured 3,834 age 1 chinook salmon, 95 age 0 chinook salmon, 19,020 hatchery steelhead trout, and 4,136 wild

Table 17. Interrogation of PIT-tagged fish from the Snake River trap, 1988-1991, and Clearwater River trap, 1989-1991, at downstream collection facilities.

Tagging Site	Year	Species[a]	Number Tagged	Number Interogated/Site Lower Granite (%)	Little Goose (%)	McNary (%)	Totals (%)
Snake	1991	CH	2131	929 (43.6)	409 (19.2)	115 (5.4)	1453 (68.2)
		SH	2577	2032 (78.9)	268 (10.4)	11 (0.4)	2311 (89.7)
		SW	3549	2266 (63.9)	625 (17.6)	66 (1.9)	2957 (83.3)
Clearwater	1991	CH	3943	1483 (37.6)	668 (16.9)	235 (6.0)	2386 (60.5)
		SH	1215	926 (76.2)	89 (7.3)	3 (0.3)	1018 (83.8)
		SW	727	409 (56.3)	102 (14.0)	28 (3.9)	539 (74.1)
Snake	1990	CH	2,245	956 (42.6)	310 (13.8)	180 (8.0)	1,446 (64.4)
		SH	3,112	2,272 (73.0)	282 (9.1)	33 (1.1)	2,587 (83.1)
		SW	3,078	2,016 (65.5)	356 (11.6)	60 (2.0)	2,432 (79.0)
Clearwater	1990	CH	4,242	1,359 (32.0)	674 (15.9)	281 (6.6)	2,314 (54.6)
		SH	1,228	880 (71.7)	63 (5.1)	10 (0.8)	953 (77.6)
		SW	1,300	767 (59.0)	126 (9.7)	22 (1.7)	915 (70.4)
Snake	1989	CH	6,222	2,384 (38.3)	1,367 (22.0)	482 (7.7)	4,233 (68.0)
		SH	2,525	1,733 (68.6)	268 (10.6)	35 (1.4)	2,036 (80.6)
		SW	1,798	1,170 (65.1)	240 (13.3)	52 (2.9)	1,462 (81.3)
Clearwater	1989	CH	2,441	756 (31.0)	452 (18.5)	140 (5.7)	1,348 (55.2)
		SH	290	173 (59.7)	16 (5.5)	2 (0.7)	191 (65.9)
		SW	104	53 (51.0)	16 (15.4)	3 (2.9)	72 (69.2)
Snake	1988	CH	3,767	1,237 (32.8)	543 (14.4)	299 (7.9)	2,079 (55.2)
		SH	1,743	1,069 (61.3)	190 (10.9)	12 (0.7)	1,271 (72.9)
		SW	1,186	698 (58.9)	166 (14.0)	20 (1.7)	884 (74.5)

[a] CH = chinook, SH = hatchery steelhead, SW = wild steelhead.

steelhead trout. The wild steelhead trout catch in the trap was greater than in any previous year, up 121% from 1990 which was the second highest year.

The Clearwater River trap was operated from March 13 through May 12, with 4 d down time in late-April and mid-May when the trap was out of operation due to high flow and heavy debris. Clearwater River trap catch was 39,522 age 1 chinook salmon, 9,231 hatchery steelhead trout, and 824 wild steelhead trout. Chinook salmon trap catch was down slightly from 1990 but similar to other drought years. Hatchery steelhead trout trap catch was similar to 1990 and wild steelhead trout trap catch was about half of 1990 but higher than other drought years.

Fish were again PIT-tagged for migration rate statistics at the Snake River trap and Clearwater River trap in 1991. The number of fish PIT-tagged at the Snake River trap was 8,363 and the number of fish PIT-tagged at the Clearwater River trap was 5,904.

Snake River trap chinook salmon efficiency tests were not conducted in 1991 due to the low catch of chinook in the trap. Previous years trap efficiencies provide a pooled average chinook salmon trap efficiency of 1.39% at the Snake River trap.

Snake River trap steelhead trout trap efficiency tests were conducted on three occasions in 1990 and provided a mean trap efficiency of 0.49%.

Chinook salmon trap efficiency at the Clearwater River trap in 1991 was 1.16% which was lower than other years except 1989. Clearwater River trap mean efficiency for hatchery steelhead trout in 1991 was not tested but it was 1.90% in 1990, which is significantly higher than in previous years when trap efficiencies were below 0.4%. The increase in trap efficiency for steelhead trout at the Clearwater River trap was probably due to several trap modifications which were made in 1988 and 1989 and the fact that the trap was fished closer to the thalweg for a greater portion of the 1990 season.

Because of the low chinook salmon freeze brand recovery at the Snake River trap in 1991, migration rate statistics were calculated for only three of the brand groups. The migration rate for all three groups was considerably lower than in previous years due to the below normal and late runoff. Freeze- branded hatchery steelhead trout migration rate to the Snake River trap was considerably slower in 1991 than in previous years.

Migration rates for Clearwater River freeze-branded chinook salmon were similar to rates observed in 1985, 1986, 1988 through 1990. In 1987 migration rate was four times slower than in 1991. Flows were considerable lower for a major portion of the migration in 1987 and probably was the reason for the slower migration that year. An accurate migration rate for hatchery steelhead trout released from DNFH could not be determined in 1991, because the freeze brands were very difficult to read.

PIT-tagged chinook salmon are a much better method of determining migration rate through Lower Granite Reservoir than using freeze brand groups. Statistical analysis showed a strong relation between migration rate and discharge for

Chinook salmon PIT-tagged at either trap (Snake River trap: $r^2 = 0.885$, $N = 13$, $P<0.001$; Clearwater River trap: $r^2 = 0.821$, $N = 10$, $P = 0.008$). As discharge increased, migration rate of PIT-tagged Chinook salmon through the reservoir also increased. PIT-tagged chinook salmon moved about twice as fast through the reservoir at 100 kcfs than at 50 kcfs. Chinook salmon PIT-tagged at the Clearwater River trap migrated about 30% slower through Lower Granite Reservoir than fish PIT-tagged at the Snake River trap.

Percent interrogation of PIT-tagged chinook salmon released from the Snake River trap was similar to 1989 and 1990. Cumulative interrogation of PIT-tagged chinook salmon at all three dams (Lower Granite, Little Goose, and McNary) was 68.2% in 1991. Percent interrogation of PIT-tagged chinook salmon released from the Clearwater River trap was slightly higher than in 1990.

There is a very strong statistical relation between migration rate and discharge for Snake River trap PIT-tagged hatchery steelhead trout ($r^2 = 0.938$, N. 13, $P<0.001$). PIT-tagged hatchery steelhead trout migrated about three times as fast at 100 kcfs as they did at 50 kcfs.

Hatchery steelhead trout PIT-tagged at the Clearwater River trap took three days longer to migrate through Lower Granite Reservoir than fish tagged at the Snake River trap. There was a relation between migration rate and discharge for the Clearwater River trap fish ($r^2 = 0.634$, $N = 11$, $P = 0.003$). The relation was not **as** strong as the one observed for the Snake River trap hatchery steelhead due to the limited data available.

The Snake River trap PIT tag data for hatchery steelhead trout were examined over years to see if there was a significant difference in the migration rate/discharge relation among years. The analysis showed there was a significant difference among years that was attributable to 1988. If 1988 data were removed, there was no statistical difference in the migration rate/discharge relation for the remaining four years data for hatchery steelhead PIT-tagged at the Snake River trap.

Percent interrogation at all three dams (Lower Granite, Little Goose, and McNary dams) of PIT-tagged hatchery steelhead trout tagged at the Snake River trap was 89.7%. This was slightly greater than in previous years. Percent interrogation at all three dams of PIT-tagged hatchery steelhead trout tagged at the Clearwater River trap was 83.8%, which was slightly higher than in 1990.

The introduction of the PIT tag has provided the opportunity to obtain travel time data through Lower Granite Reservoir for wild steelhead trout. This is because of the low numbers of fish required for marking due to the high recovery rate at Lower Granite Dam. Wild steelhead trout PIT-tagged at the Snake River trap migrated at a rate of 13.6 km/d. The relation between migration rate and discharge for wild steelhead trout was very strong ($r^2 = 0.873$, $N = 15$, $P<0.001$). These fish migrated twice as fast through Lower Granite Reservoir at 100 kcfs as they did at 50 kcfs. PIT-tagged wild steelhead trout migrate slightly faster through Lower Granite Reservoir than did the PIT-tagged hatchery steelhead trout.

Wild steelhead trout were collected and PIT-tagged at the Clearwater River trap in 1991 at a rate to provide enough data to examine migration rate through Lower Granite Reservoir. Clearwater River wild steelhead trout mean migrated at 9.8 km/d through Lower Granite Reservoir. This was 3.8 km/d slower than the mean for wild steelhead trout PIT-tagged at the Snake River trap.

There was a very strong relation between migration rate and discharge for PIT-tagged wild steelhead trout released from the Clearwater River trap (r^2 = 0.921, N = 10, P<0.001). Clearwater River wild steelhead trout migrated twice as fast at 100 kcfs as they did at 50 kcfs. Migration rate through the reservoir for Clearwater and Snake rivers wild steelhead trout at higher discharge was about the same (e.g., at 100 kcfs, 22.0 km/d and 20.3 km/d, respectively).

The migration rate/discharge relations for wild steelhead trout for 1987-1991 were examined to see if there was a difference among years. There was no significant difference among years (i.e., homogenous slopes and common intercepts were accepted) for wild steelhead trout, and the data were pooled. The linear regression analysis on this pooled data showed a very strong relation between migration rate and discharge (r^2 = 0.821, N = 55, P<0.001).

Percent interrogation of PIT-tagged wild steelhead trout marked at the Snake River or Clearwater River traps was slightly higher than in previous years. Cumulative interrogation of PIT-tagged wild steelhead trout at the three dams (Lower Granite, Little Goose, and McNary) was 83.3% for Snake River trap fish and 74.1% for Clearwater River trap fish in 1991. Percent interrogation of PIT-tagged wild steelhead trout from the Clearwater River trap was significantly lower than for fish PIT-tagged at the Snake River trap.

The migration rate/discharge relation for chinook salmon between the traps and Little Goose Dam was examined. The analysis showed that 72% of the variation in migration rate for chinook salmon PIT-tagged at the Snake River trap was accounted for by discharge. It also showed that 83% of the variation in migration rate for Clearwater River chinook salmon was accounted for by changes in discharge.

The migration rate/discharge relation for hatchery steelhead trout between the traps and Little Goose Dam was examined. Seventy-one percent of the variation in migration rate of fish PIT-tagged at the Snake River trap was accounted for by discharge. Not enough data were available to examine the migration rate discharge relation of hatchery steelhead trout marked at the Clearwater River trap.

The migration rate/discharge relation for wild steelhead trout between the traps and Little Goose Dam was examined. The analysis showed that 93% of the variation in migration rate of fish PIT-tagged at the Snake River trap was accounted for by discharge. Not enough data were available to perform the analysis on wild steelhead PIT-tagged at the Clearwater River trap.

Chinook salmon, hatchery steelhead trout, and wild steelhead trout PIT-tagged at the Snake River trap survived at a rate 6% to 9% greater than fish tagged at the Clearwater River trap. This assumes similar fish guiding efficiency at the dams for fish from the both rivers.

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